DRAFT

Analysis of Fine Particulate Matter ($PM_{2.5}$) in Indiana 2000 - 2003

Indiana Department of Environmental Management
Office of Air Quality
100 North Senate Ave
PO Box 6015
Indianapolis, IN 46206-6015

January 2004

Table of Contents

List of Figures

Section 1: Overview……1

Section 2: Background……1

Section 3: Indiana's $PM_{2.5}$ Network……1

Section 4: Data Analysis……2
4.1 Overview
4.2 Limitations
4.3 Data Analysis Methodology
4.4 Annual Standard
4.5 24-Hour Standard
4.6 Urban/Rural Comparison
4.7 $PM_{2.5}$ Data and Regional Comparison
4.8 $PM_{2.5}$ Values Compared to Ozone Values
4.8.1 PM2.5 Values Compared to Ozone Values (June 21-22, 2002)

Section 5: Seasonal and Geographic Variability……13
5.1 Spatial Patterns
5.2 Temporal Profiles

Section 6: Speciated Data……..19
6.1 Speciated Data Findings

Section 7: Conclusions……..25

Appendix A……27
Map of PM2.5 sites in Indiana

Appendix B……29
Table outlining Annual and 24-Hour Standard comparisons for each site

Appendix C……33
Urban/Rural Comparison between Vincennes and Indianapolis

Appendix D……41
PM2.5 Atmospheric Streamlines

References

List of Figures

Tables

Table 1: National Air Quality Standards for $PM_{2.5}$
Table 2: Annual Averages
Table 3: 24-Hour Values
Table 4: $PM_{2.5}$ Northern Region Comparison
Table 5: $PM_{2.5}$ Southern Region Comparison

Maps

Map 1: $PM_{2.5}$ Annual Values
Map 2: 1999 MSA Boundaries for Counties with $PM_{2.5}$ Monitors Above or Near the Annual Standard
Map 3: 2003 MSA Boundaries for Counties with $PM_{2.5}$ Monitors Above or Near the Annual Standard
Map 4: $PM_{2.5}$ 24-hour Values

Figures

Figure 1: Ozone/$PM_{2.5}$ June 16 - June 27, 2002
Figure 2: Ozone/$PM_{2.5}$ July 1 - July 6, 2002
Figure 3: Ozone/$PM_{2.5}$ July 4 – July 21, 2002
Figure 4: Ozone/$PM_{2.5}$ July 27 – August 7, 2002
Figure 5: 2000 Spatial Comparison
Figure 6: 2001 Spatial Comparison
Figure 7: 2002 Spatial Comparison
Figure 8: 3-Year Spatial Comparison
Figure 9: 2000 Temporal Comparison
Figure 10: 2001 Temporal Compairson
Figure 11: 2002 Temporal Comparison
Figure 12: 3-Year Temporal Comparison
Figure 13: Indianapolis Speciated Data for July 21, 2001
Figure 14: Indianapolis Speciated Data for August 2, 2001
Figure 15: Indianapolis Speciated Data for August 8, 2001
Figure 16: Indianapolis Speciated Data for November 18, 2001
Figure 17: Indianapolis Speciated Data for 1st Quarter 2001
Figure 18: Indianapolis Speciated Data for 2nd Quarter 2001
Figure 19: Indianapolis Speciated Data for 3rd Quarter 2001
Figure 20: Indianapolis Speciated Data for 4th Quarter 2001
Figure 21: Indianapolis Speciated Data for June 22, 2002
Figure 22: Indianapolis Speciated Data for July 4, 2002
Figure 23: Indianapolis Speciated Data for September 8, 2002
Figure 24: Indianapolis Speciated Data for December 7, 2002
Figure 25: Indianapolis Speciated Data for 1st Quarter 2002
Figure 26: Indianapolis Speciated Data for 2nd Quarter 2002
Figure 27: Indianapolis Speciated Data for 3rd Quarter 2002
Figure 28: Indianapolis Speciated Data for 4th Quarter 2002
Figure 29: Mechanicsburg Speciated Data for June 19, 2002
Figure 30: Mechanicsburg Speciated Data for June 22, 2002
Figure 31: Mechanicsburg Speciated Data for July 4, 2002
Figure 32: Mechanicsburg Speciated Data for August 12, 2002
Figure 33: Mechanicsburg Speciated Data for 1st Quarter 2002
Figure 34: Mechanicsburg Speciated Data for 2nd Quarter 2002
Figure 35: Mechanicsburg Speciated Data for 3rd Quarter 2002
Figure 36: Mechanicsburg Speciated Data for 4th Quarter 2002

Appendices

Appendix A: Map of $PM_{2.5}$ Sites in Indiana
Appendix B: Annual and 24-Hour Standard Values
Appendix C: Vincennes vs. Indy Quarterly Comparisons
Appendix D: Atmospheric Streamlines

Analysis of Fine Particulate Matter ($PM_{2.5}$) Monitored Data for the Years 2000 to 2003

1. OVERVIEW

In December 2004, based on three years of monitoring data, US EPA will be designating areas that do not meet the $PM_{2.5}$ standards as nonattainment. By February 2004, Indiana is expected to provide recommendations to US EPA concerning how counties in Indiana should be designated under the standard. An analysis was performed on fine particulate matter ($PM_{2.5}$) monitoring data collected in Indiana up through 3rd Quarter 2003. EPA will use 2001 through 2003 data to determine nonattainment areas.

In addition to assessing available data in reference to the federal air quality standards, this analysis, to the extent possible, also looked at other metrics that might provide more insight into air quality in Indiana with respect to $PM_{2.5,}$ such as possible local and regional influences and seasonal and geographic influences.

The Midwest Regional Planning Organization (RPO) has conducted an analysis of $PM_{2.5}$ on a much broader scale, investigating characteristics across Midwestern states. The analysis herein is focused on a more local scale, investigating $PM_{2.5}$ data as it relates solely to the state of Indiana. This report summarizes findings of the three-year analysis.

2. BACKGROUND

Particulate matter, or PM, consists of particles found in smoke, soot and liquids. These particles can range in size from ash that is visible from a fire to something so small that it can only be seen through a microscope. They can be emitted into the air from sources such as automobiles, gravel roads, factories and fuel combustion. The particles can also contain other chemical species such as nitrates, sulfates and metals. Particulate matter causes concern because it contributes to lung ailments such as bronchitis and asthma and causes visibility degradation. It can also travel long distances and be deposited in lakes and streams, making them acidic, and damage buildings.

Fine particulate matter, or $PM_{2.5}$ (particles with a diameter of 2.5 micrometers or less), has raised concern recently because it is associated with increased respiratory problems. These particles can be emitted directly from vehicle exhaust, fuel combustion from industries such as utilities, and residential combustion activities such as woodburning stoves. Sulfates, nitrates and their species emitted from various sources may also form fine particulates from secondary reactions.

Evidence suggests that fine particulate matter is of most concern from a public health standpoint. The US EPA estimates that tens of thousands of elderly individuals die prematurely each year from exposure to fine particles. It also contributes to an increase in childhood illnesses and emergency room visits by sensitive populations already suffering from emphysema and chronic bronchitis.

As a result, in 1997 US EPA revised the PM standard to include new annual (15 $\mu g/m^3$) and 24-hour (65 $\mu g/m^3$) $PM_{2.5}$ standards. The annual standard is met when the 3-year average of the annual mean concentrations across a designated area is less than or equal to 15$\mu g/m^3$ (micrograms per cubic meter). The 24-hour standard is met when the 3-year average of the 98th percentile of the 24-hour concentrations at each monitor in an area is less than or equal to 65 $\mu g/m^3$. The US EPA has indicated that they plan to reassess the fine particulate matter standard after 3 years of air quality data have been collected. The National Air Quality Standard for $PM_{2.5}$ can be found in Table 1 below.

National Air Quality Standards for $PM_{2.5}$ (Table 1)

$PM_{2.5}$	Standard Value	Standard Type
Annual Arithmetic Mean	15.0 $\mu g/m^3$	Primary and Secondary
24-Hour Average	65.0 $\mu g/m^3$	Primary and Secondary

3. INDIANA'S $PM_{2.5}$ NETWORK

Starting in 1999, the Indiana Department of Environmental Management (IDEM) established a fine particulate monitoring network throughout the state to measure $PM_{2.5}$ concentrations. The Indiana $PM_{2.5}$ monitoring network consists of 40 sites located in the most populated areas of the state. These monitors sample air quality either daily or once every three days. Each monitoring site is designated as a State and Local Monitoring Station (SLAMS). SLAMS sites are designed and operated by state or local pollution control agencies and are used to determine the concentrations of particulate matter in high population density areas. Appendix A contains a map of all monitors within the $PM_{2.5}$ monitoring network.

4. DATA ANALYSIS

4.1 Overview

Several different analyses were conducted to gain insight into the characteristics of $PM_{2.5}$ throughout Indiana. A comparison of monitored data to both daily and annual standards was made as a basis for the analysis. $PM_{2.5}$ values were compared across urban, rural and regional sites to determine if any correlation existed. An analysis was also conducted to determine the characteristics of $PM_{2.5}$ values during episodes of high ozone. Spatial, temporal and speciated $PM_{2.5}$ data were also reviewed.

4.2 Limitations

During the preparation of this $PM_{2.5}$ data analysis, several limitations in the monitored data were encountered. These limitations did not allow certain parts of the analysis to be completed in a thorough fashion. The limitations are listed below.

- The monitor in Spencer County (147-0009) is a one in six day monitor and did not collect enough samples in the month of June leaving the second quarter incomplete making it invalid for the whole year.
- One of the Indianapolis monitors (097-0081) was temporarily shut down while the building underwent repairs in the Third Quarter of 2002. No data was collected for this monitor from May 1st through September 30th rendering the data for the year 2002 unusable.
- The monitor in Lafayette (157-0007) was shut down at the end of July in 2002 and relocated to a new site in October 2002. Third and fourth Quarter data for the year 2002 were not collected for this monitor rendering the data for the year invalid.
- The Gary Federal Building monitor (089-1016) was shut down in September of 2002. Forth Quarter data for the year 2002 was not collected for this monitor rendering the data for the year invalid. 1999 data was reviewed to see if there were three complete years of data. 1999 data was complete so the three years of data that were used to compare to the annual and daily standards for this monitor came from the years 1999, 2000 and 2001.
- The monitor in Jeffersonville was relocated to a new site in the 3rd Quarter of 2003.
- Two monitors in Gary (089-0022, 089-0026) and two monitors in Indianapolis (097-0043, 097-0066) are local hot spot source oriented monitors and were not compared to the annual standard. The Gary IITRI monitor (089-0022) is classified as a high concentration continuous monitor and was also not compared to the daily standard.[1]

4.3 Data Analysis Methodology

The US EPA developed the "Guideline for Data Handling Conventions for the PM NAAQS" released in April of 1999, to assess compliance with the standard. Compliance is determined two ways: The annual standard is found using a 3-year average of the annual mean concentration across a monitor and the 24-hour standard is determined by using the 3-year average of the 98th percentile of the 24-hour concentrations at the monitor. Please refer to Appendix B for an information table that outlines the annual and 24-hour standard comparisons for each site.

[1]These monitors were not compared to the standards in accordance with US EPA's "Guideline on Data Handling Conventions for the PM NAAQS", USEPA, OAQPS, April 1999 and 40 CFR Part 58.

4.4 Annual Standard

The annual average is calculated for each individual monitoring site, using the average of the sum of the annual averages for each location. The 3-year average annual mean was calculated at each monitor. To do this, the quarterly means were calculated for each site. Using the quarterly means, the annual mean was then calculated. After this was done for each year, all three years were averaged together to determine the 3-year average annual mean for that monitor. All concentrations then were rounded to the nearest 0.1μg/m^3 before being compared to the standard. The standard is met when an individual monitor measures 15.0 μg/m^3 or below. Any value above this is a violation of the standard.

There are 40 total PM2.5 sites in Indiana and based on the 2001 to 3rd Quarter 2003 data 17 of them exceeded the annual standard. The E. Michigan Street monitor in Indianapolis had the highest 3-year average value with 17.1 μg/m^3. All together 5 monitors in Indianapolis, 3 monitors in Evansville, 2 monitors in Hammond and Gary, and one each in East Chicago, Elkhart, Jasper, New Albany and Jeffersonville exceeded the standard. Two monitors in Gary (089-0022 and 089-0026) and two monitors in Indianapolis (097-0043 and 097-0066) are source oriented monitors and were not compared to the annual standard. Table 2 contains the 3-year averages for each monitor.

Based on the 2001 to 3rd Quarter 2003 averages for each individual monitor seven counties currently exceed the annual standard. Lake, Elkhart, Marion, Vanderburgh, Dubois, Clark and Floyd currently exceed based on a 3-year average. Tippecanoe County exceeds the standard based on a 2-year average at the old location The new location in Tippecanoe County currently shows the monitor under the standard. Howard, Delaware and Vigo Counties were above the standard in 2000 to 2002, but are currently under the standard; the status is dependent on the 4th Quarter 2003 data and values are predicted not to exceed the standard. Porter, LaPorte, St. Joseph, Allen, and Madison Counties are currently under the standard based on a 3-year average. EPA guidance suggest that Metropolitan Statistical Areas (MSAs) should serve as the presumptive boundary for urban $PM_{2.5}$ NAAQS nonattainment areas, not just the county where the monitor is in violation. Doing this would provide a better definition of the source area that contributes to the $PM_{2.5}$ nonattainment problems. A map of the 1999 and 2003 MSA boundaries with $PM_{2.5}$ monitors above or near the annual standard follows.

Annual Averages (Table 2)
2001 through 3rd Quarter 2003 Data

Note: Highlighted data exceeds the Annual Standard

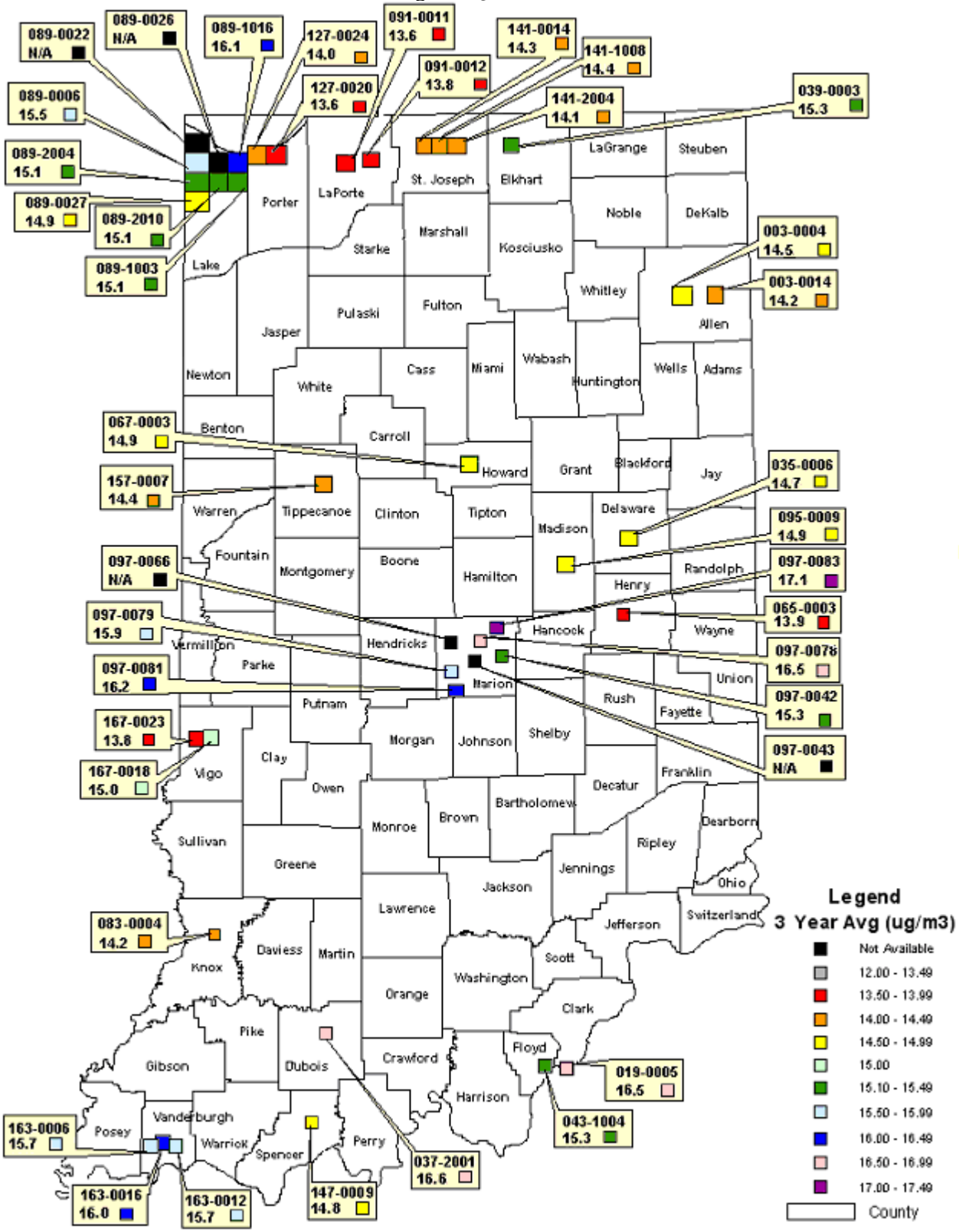
Monitor	County	3-Yr Average (μg/m^3)		Monitor	County	3-Yr Average (μg/m^3)
003-0004	Allen	14.5		095-0009	Madison	14.9
003-0014	Allen	14.2		097-0042	Marion	15.3
019-0005/6	Clark	16.5†		097-0043	Marion	N/A*
035-0006	Delaware	14.7		097-0066	Marion	N/A*
037-2001	Dubois	16.6		097-0078	Marion	16.5
039-0003	Elkhart	15.3		097-0079	Marion	15.9
043-1004	Floyd	15.3		097-0081	Marion	16.2
065-0003	Henry	13.9		097-0083	Marion	17.1
067-0003	Howard	14.9		127-0020	Porter	13.6
083-0004	Knox	14.2		127-0024	Porter	14.0
089-0006	Lake	15.5		141-0014	St. Joseph	14.3
089-0022	Lake	N/A*		141-1008	St. Joseph	14.4
089-0026	Lake	N/A*		141-2004	St. Joseph	14.1
089-0027	Lake	14.9		147-0009	Spencer	14.8
089-1003	Lake	15.1		157-0008	Tippecanoe	14.4❑
089-1016	Lake	16.1▼		163-0006	Vanderburgh	15.7
089-2004	Lake	15.1		163-0012	Vanderburgh	15.7
089-2010	Lake	15.1		163-0016	Vanderburgh	16.0
091-0011	LaPorte	13.6		167-0018	Vigo	15.0
091-0012	LaPorte	13.8		167-0023	Vigo	13.8

* These are source oriented monitors and were not compared to the annual standard[2]
❑ Data value from new monitoring location
† Data value combined from old and new monitoring location
▼ Data value from 2000 to Sept 2002, Monitor shut down in September 2002

[2] These monitors were not compared to the standards in accordance with US EPA's "Guideline on Data Handling Conventions for the PM NAAQS", USEPA, OAQPS, April 1999 and 40 CFR Part 58.

PM 2.5 Annual Values

2001 through 3rd Quarter 2003 Data



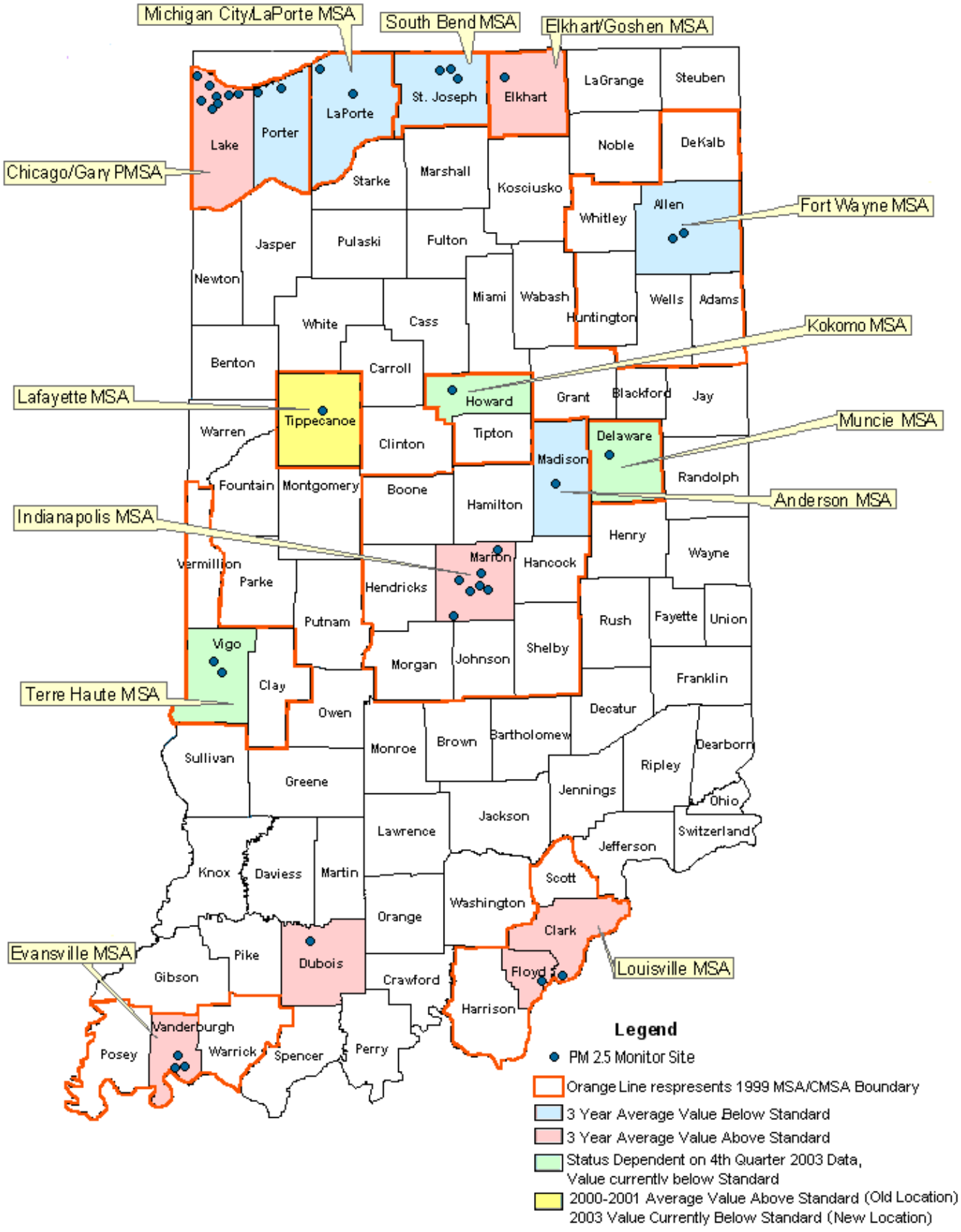
****065-0003 is the Regional Transport Monitor**

****083-0004 is the Background Monitor**

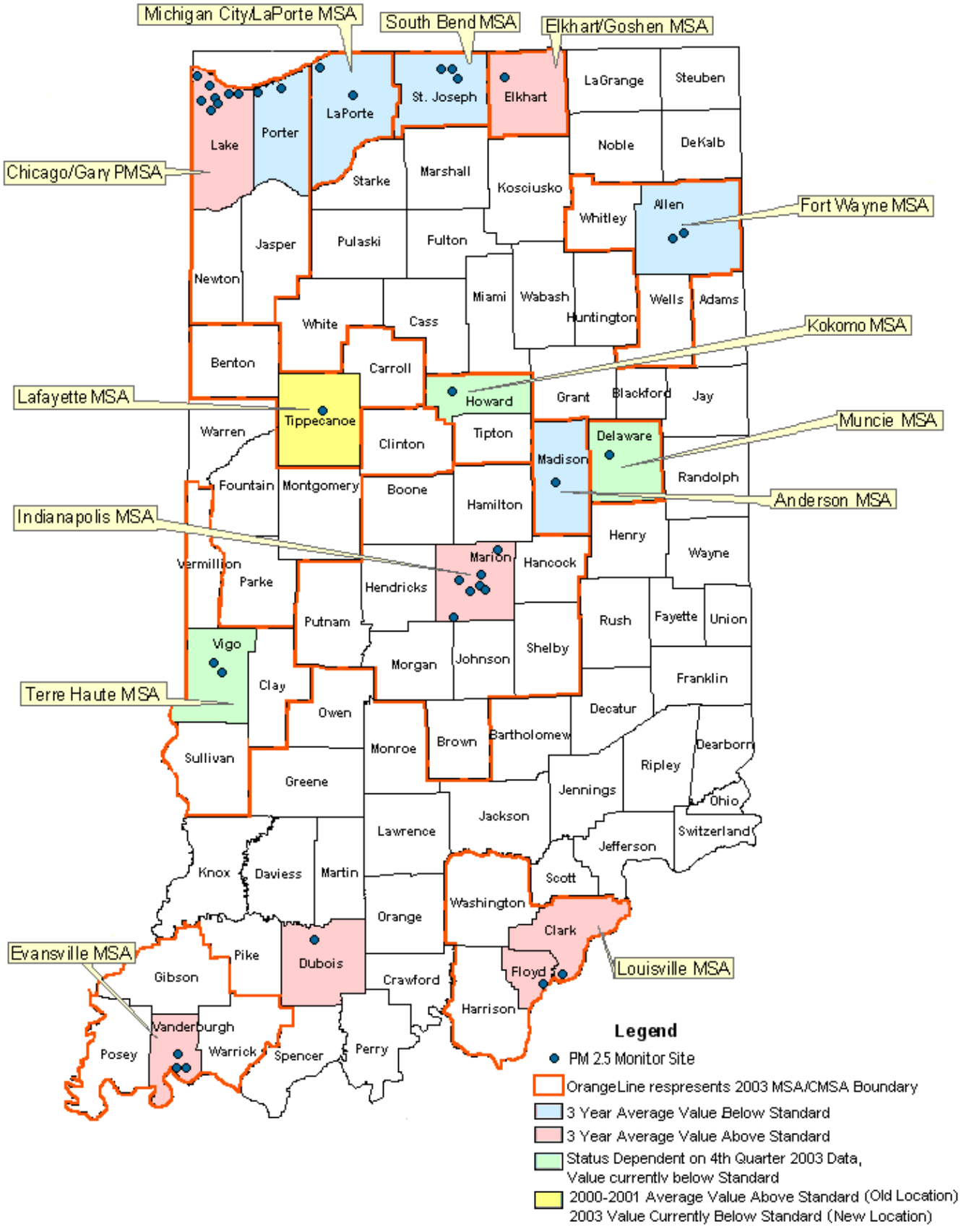
****089-0022, 089-0026, 097-0043 and 097-0066 are not compared to the Annual Standard**

****The Annual Standard is met when a value is ≤ 15.0 ug/m3**

1999 MSA Boundaries for Counties with $PM_{2.5}$ Monitors
2001 through 3rd Quarter 2003 Data



2003 MSA Boundaries for Counties with $PM_{2.5}$ Monitors
2001 through 3rd Quarter 2003 Data



4.5 24-Hour Standard

There are 40 total $PM_{2.5}$ sites in Indiana and the 24-hour standard was not exceeded at any monitor. The average value across the state was 36 $\mu g/m^3$. The Gary IITRI Monitor (18-089-0022) was not compared to the 24-Hour standard since the monitor is source oriented and a continuous monitor. The highest values were found in Jeffersonville and the English Ave site in Indianapolis which both had a 3-year average of 43 $\mu g/m^3$. The lowest value was in Spencer County with a 3-year average of 30$\mu g/m^3$. Calculating the 3-year average 98th percentile for $PM_{2.5}$ first consisted of sorting all data values collected in each year from lowest to highest. A rank was assigned to each data value. In order to find the 98th percentile, the number of values in each year was multiplied by 0.98, and the value of 1 was added to the integer part of the answer. The corresponding value for the rank was the 98th percentile. The 3-year average of all of the values for the 98th percentile were calculated and rounded to the nearest integer.[3] The standard is met when an individual monitor measures 65.0 $\mu g/m^3$ or below. Any value above this is a violation of the standard. A map of the 24-Hour Values follows. Table 3 contains the 24-hour average values for each individual monitor. An abbreviated example calculation for one monitor follows:

1. All data values for the site for each year of data are sorted from lowest to highest.
   Example Site 1, Year 1: 21, 24.6, 25.6, 28, 31, 34, 36.5, 41, 45.3, 51.2
   Example Site 1, Year 2: 25, 27.8, 29.4, 29.6, 30.2, 30.9, 34.7, 41, 43.2, 45.2
2. A rank is then assigned to each value.
   Example Site 1, Year 1: 1=21, 2=24.6, 3=25.6, 4=28, 5=31, 6=34, 7=36.5, 8=41, 9=45.3, 10=51.2
   Example Site 1, Year 2: 1=25, 2=27.8, 3=29.4, 4=29.6, 5=30.2, 6=30.9, 7=34.7, 8=41, 9=43.2, 10=45.2
3. The total number of data values for each site for the entire year is multiplied by 0.98 and the value of 1 is added to the integer part of the answer.
   Example: Since there are 10 values for Year 1 and Year 2, as shown in Step 2., 0.98 is multiplied by 10, which equals 9.8. The integer part of the answer is 9. When the value of 1 is added, the answer is 10. That is the ranking of the 98th percentile.
4. The answer would be 51.2 for Year 1 and 45.2 for Year 2, since those are the values with the ranks of 10.
5. Steps 1-4 are repeated for each year that values are recorded.
6. The answers to Step 4 for each year of data for each site are then averaged to give the average value for the site.
   Example: The average of 51.2 and 45.2 is 48.2, so that is the average value for the site.
7. This is the final value that is compared to the standard.

24-Hour Values (Table 3)
2001 through 3rd Quarter 2003 Data

Note: None of the monitors exceeded the standard

Monitor	County	3-Yr 98th Percentile Average ($\mu g/m^3$)		Monitor	County	3-Yr 98th Percentile Average ($\mu g/m^3$)
003-0004	Allen	33		095-0009	Madison	36
003-0014	Allen	36		097-0042	Marion	35
019-0005	Clark	40		097-0043	Marion	37
035-0006	Delaware	34		097-0066	Marion	43
037-2001	Dubois	38		097-0078	Marion	39
039-0003	Elkhart	35		097-0079	Marion	36
043-1004	Floyd	38		097-0081	Marion	34
065-0003	Henry	31		097-0083	Marion	38
067-0003	Howard	34		127-0020	Porter	32
083-0004	Knox	35		127-0024	Porter	33
089-0006	Lake	37		141-0014	St. Joseph	33
089-0022	Lake	N/A*		141-1008	St. Joseph	34
089-0026	Lake	41		141-2004	St. Joseph	33
089-0027	Lake	35		147-0009	Spencer	30
089-1003	Lake	34		157-0007	Tippecanoe	32
089-1016	Lake	38		163-0006	Vanderburgh	39
089-2004	Lake	34		163-0012	Vanderburgh	38
089-2010	Lake	37		163-0016	Vanderburgh	40
091-0011	LaPorte	32		167-0018	Vigo	38
091-0012	LaPorte	32		167-0023	Vigo	35

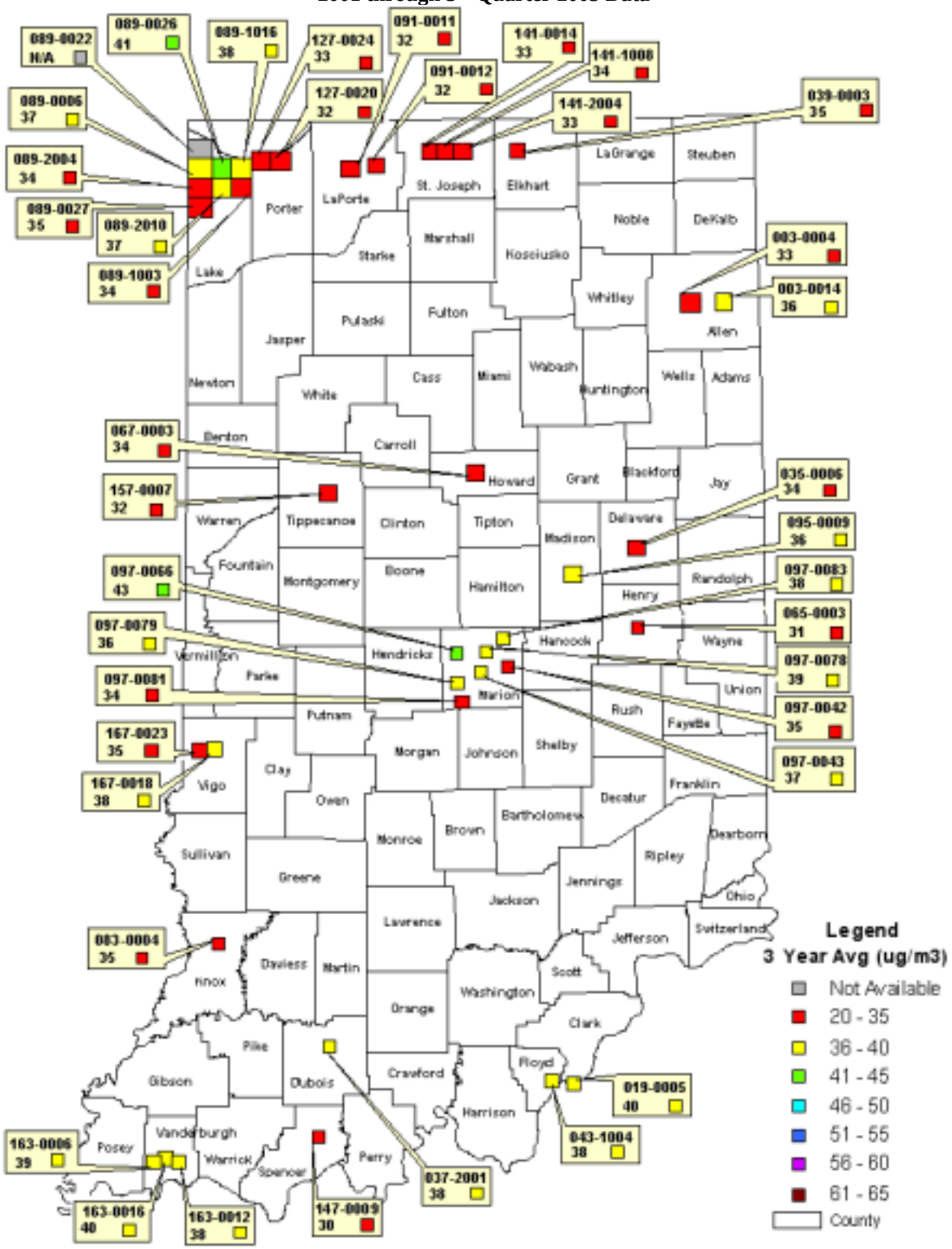
* This is a source oriented monitor and was not compared to the 24-hour standard[4]

[3]The 3-yr 98th percentile average was calculated in accordance with US EPA guidance "Guideline on Data Handling Conventions for the PM NAAQS", USEPA, OAQPS, April 1999

[4] These monitors were not compared to the standards in accordance with US EPA's "Guideline on Data Handling Conventions for the PM NAAQS", USEPA, OAQPS, April 1999 and 40 CFR Part 58.

PM 2.5 24-Hour Values

2001 through 3rd Quarter 2003 Data



****065-0003 is the Regional Transport Monitor**
****083-0004 is the Background Monitor**
****089-0022 is not compared to the 24-Hour Standard**
****The 24-Hour Standard is met when a value is ≤ 65 ug/m3**

4.6 Urban/Rural Comparison

A comparison was made between the results at urban and rural sites to see if any differences existed regionally. Comparisons were made for each quarter of 2000, 2001 and 2002, starting with the month of January. 2003 Data will be added once it is quality assured. The sites located at Mann Road and Washington Park in Indianapolis were used to represent the Indianapolis Urban Area. The South West Purdue Agriculture Center in Vincennes was used as the rural site since this monitor was set up to be the background monitor for the Indianapolis area. The data from the Indianapolis area and Vincennes appear to directly correlate. On days with high $PM_{2.5}$ values in Indianapolis, Vincennes showed elevated levels. When $PM_{2.5}$ values in Indianapolis were low, Vincennes levels were low as well. Appendix C contains quarterly graphs comparing the sites for all three years.

4.7 $PM_{2.5}$ Data and Regional Comparison

A data comparison was made between various Indiana locations and neighboring cities of other States. Annual $PM_{2.5}$ averages and 24-Hour averages were calculated for each year. $PM_{2.5}$ data collected by monitors in Northwest Indiana were compared to data collected in Chicago, Illinois. Data collected in Evansville were compared to data measured in Henderson, Kentucky. Also, data collected in New Albany were compared to $PM_{2.5}$ data for Louisville, Kentucky. The EPA AIRS program provided the $PM_{2.5}$ data.

The 2000, 2001 and 2002 $PM_{2.5}$ data comparison between Chicago, IL and Northwest Indiana reveal a contrasting pattern in relation to annual $PM_{2.5}$ average and the 24-Hour average for each state. $PM_{2.5}$ averages were found to be consistently higher in Chicago than in Northwest Indiana for both the Annual and 24-Hour averages. Data was collected from six monitors in Chicago, IL and eight monitors in Lake and Porter Counties, Indiana. Please refer to Table 4 for the $PM_{2.5}$ values. 2003 Data will be added once it is quality assured.

$PM_{2.5}$ Northern Region Comparison (Table 4)

	2000		2001		2002	
	NW Indiana	**Chicago**	**NW Indiana**	**Chicago**	**NW Indiana**	**Chicago**
Annual Average for Year	14.8	17.0	15.2	17.4	14.7	15.6
24-Hour Average for Year	33	37	37	41	34	36

A comparison of the three-year annual average and 24-hour average was calculated for Evansville, IN, Henderson, KY, New Albany, IN and Louisville, KY. The comparison shows that over a three-year period the averages in Kentucky were higher than the averages in Indiana. Please refer to Table 5 for the $PM_{2.5}$ averages. Data Values in the table are a three year average from 2000 to 2002. A new three year average will be calculated once 2003 Data is quality assured.

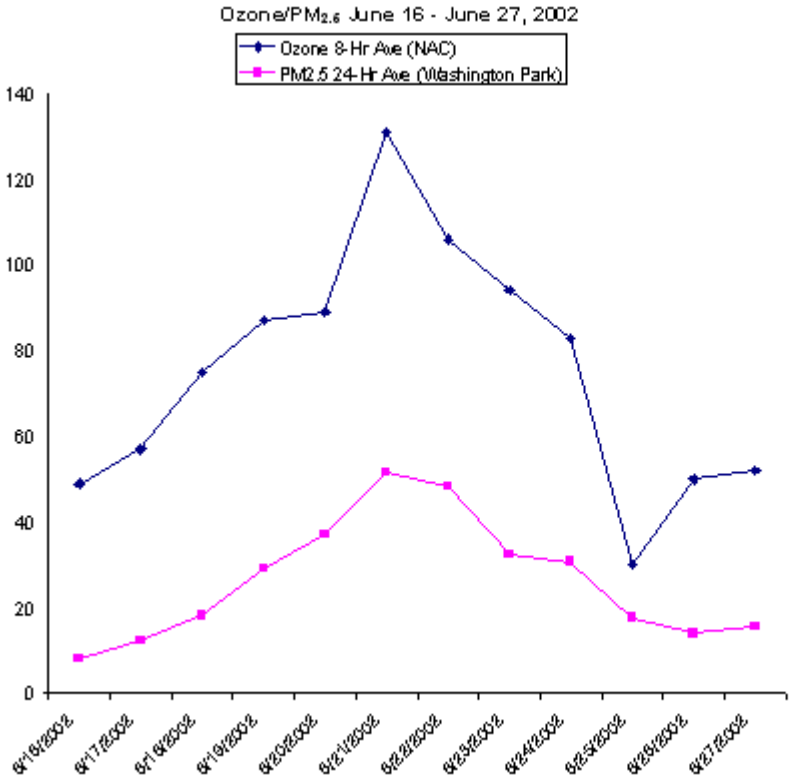
$PM_{2.5}$ Southern Region Comparison (Table 5)

	Henderson, KY	**Evansville**	**Louisville, KY**	**New Albany**
3 Year Annual Average	17.7	15.6	17.0	15.5
3-Year 24-Hour Average	44	39	41	39

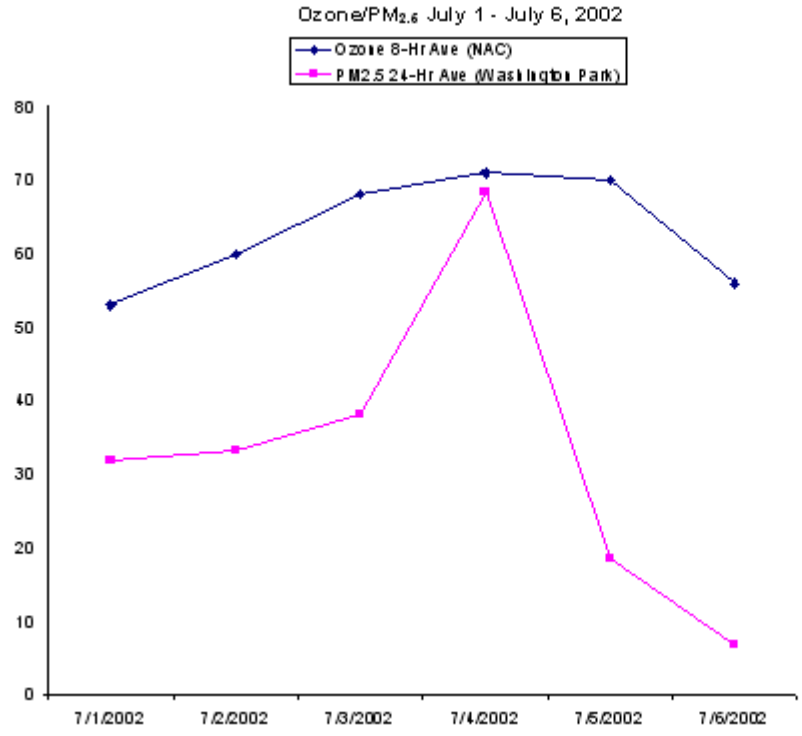
4.8 $PM_{2.5}$ Values Compared to Ozone Values

A comparison was made between $PM_{2.5}$ and ground-level ozone values during high ozone episodes that occurred during the summer of 2002. This comparison was made because it was believed that there would be a correlation between the two pollutants. For instance, it is expected that an increase in sulfates might occur concurrently with an increase in nitrates. Whole nitrates may react to increase ozone levels, while sulfates may increase fine PM levels. The maximum 8-hour average ozone values were taken from the monitor located at the Naval Avionics Center in Indianapolis that tracks values hourly. The average 24-hour $PM_{2.5}$ values were taken from the nearby monitor located at Washington Park that also tracks values hourly. Comparisons were made on 2002 episodes that occurred from June 16 – June 27 (Episode 1), July 1 – July 6 (Episode 2), July 4 – July 21 (Episode 3) and July 27 – August 7 (Episode 4). The hourly $PM_{2.5}$ values for each day at each monitor were averaged to create daily totals. The totals were then compared over the duration of the episodes. The results appear to show that there is a direct correlation between ozone levels and $PM_{2.5}$ values. This is consistent with other studies that have been conducted by the Midwest RPO and US EPA. Visual comparisons of the episodes follow.

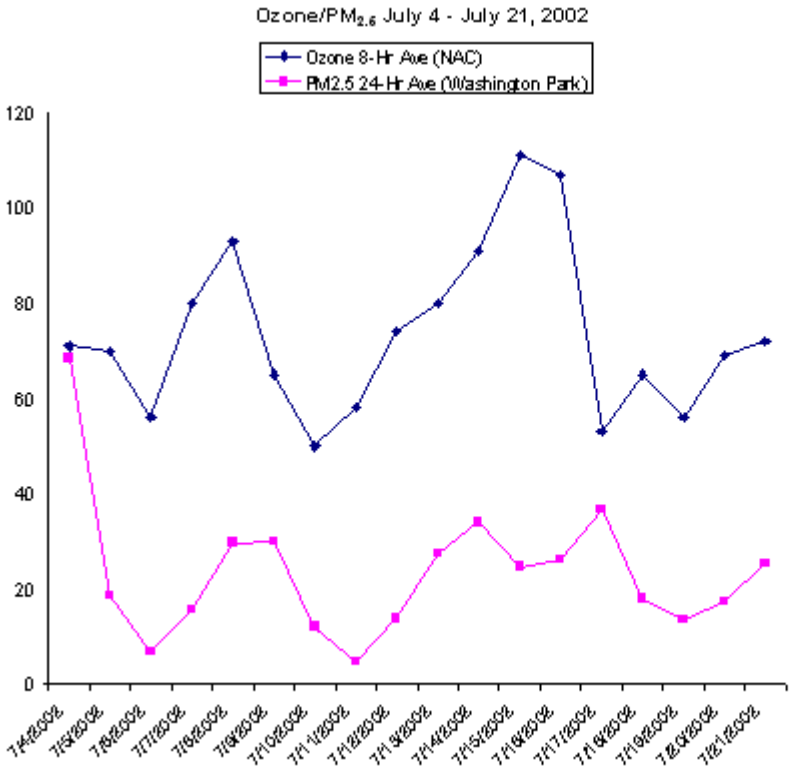
Ozone Episode 1 (Figure 1)



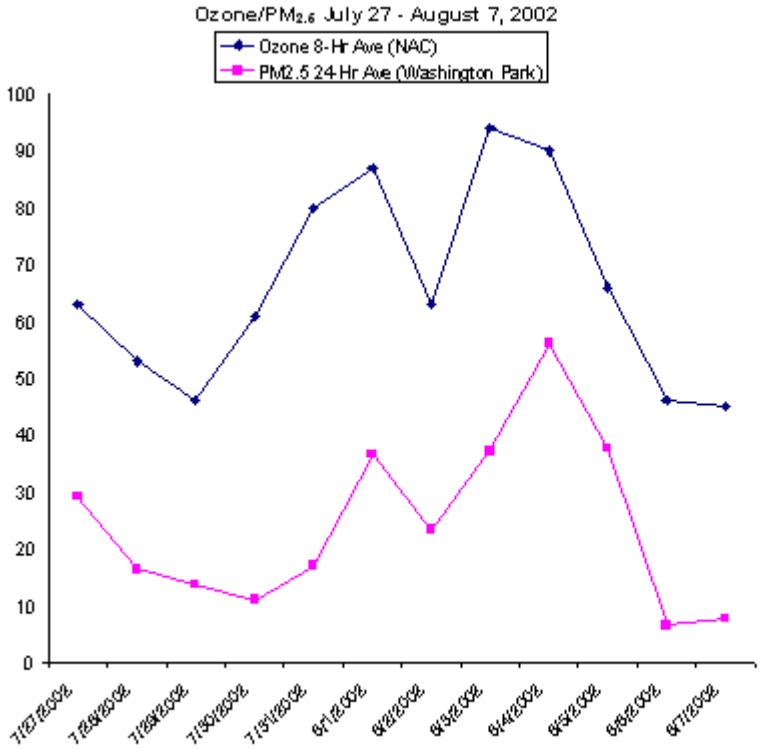
Ozone Episode 2 (Figure 2)



Ozone Episode 3 (Figure 3)



Ozone Episode 4 (Figure 4)



4.8.1 An examination of $PM_{2.5}$ values observed during an episode of high ground-level ozone occurring over the Indianapolis, Indiana, area on the 21st through 22nd of June 2002

On 21 June 2002, the Indianapolis, Indiana, area's four ozone monitors recorded one-hour ground-level ozone (O_3) values of 142 parts per billion (ppb), 131 ppb, 129 ppb, less than 125 ppb. The eight-hour ground-level O_3 readings observed were 131 ppb, 118 ppb, 112 ppb, and 103 ppb. The one-hour O_3 standard is 125 ppb and the eight-hour O_3 standard is 85 ppb.

On 22 June 2002, one of the Indianapolis, Indiana, area's ozone monitors recorded an one-hour ground-level O_3 value of 130 ppb. (All other one-hour readings were less than 125 ppb.) The eight-hour ground-level O_3 values observed were 111 ppb, 106 ppb, 105 ppb, and 101 ppb.

Both the one-hour and the eight-hour O_3 standards were exceeded in Marion County, Indiana, on each day of the event.

With respect to $PM_{2.5}$, Marion County, Indiana, has 7 monitoring sites. On the 21 June 2002 only one site reported a value. The 24-hour average ground-level value reported was 50.0 micrograms per cubic meter (ug/m^3). The 24-hour $PM_{2.5}$ standard is 65 ug/m^3. On 22 June 2002, nine sites reported values ranging from 49.2 ug/m^3 to 45.8 ug/m^3.

The 24-hour $PM_{2.5}$ standard was not exceeded on either day. However, the $PM_{2.5}$ values monitored both on 21 June 2002 and on 22 June 2002 were the highest recorded for the month of June 2002 in Marion County, Indiana.

Meteorological reconstructions of atmospheric conditions existing at the earth's surface and above were performed for this O_3 and $PM_{2.5}$ episode. The reconstructions start at 7:00 P.M. EST 20 June 2002 (the day before the episode was most pronounced) and end at 7:00 P.M. EST 22 June 2002. The meteorological variable analyzed was streamlines of wind direction. Streamlines are lines drawn parallel with the wind flow. They are a function of wind direction and not velocity and are not drawn through regions where the wind speeds are one knot or less. A streamline analysis was chosen since $PM_{2.5}$ is primarily transported by the wind and thus source regions can perhaps be identified. Streamlines were generated for the following atmospheric levels: surface, 5000 feet above ground-level (AGL), 10,000 feet AGL, and 18,000 feet AGL (Appendix D: Figures 1 through 24).

The surface streamline analysis (Figures 1 through 9) shows several interesting features that more than likely contributed to the monitored values of $PM_{2.5}$ that occurred on 21 June 2002 and 22 June 2002:

- The development of calm surface winds (as evidenced by the lack of streamlines in central Indiana, Figures 2 and 3) after midnight on the 21 June 2002 continuing into the morning of that day. This period of calm surface winds would, more than likely, have enhanced particulate settling over central Indiana.
- The development of an area of confluent (i.e., flowing together) streamlines across central Indiana (Figure 5). This feature would imply a heightened transport of the air mass existing over east central Indiana and west central Ohio into the Indianapolis area.
- Once again the development of calm surface winds (as evidenced by the near lack of streamlines in central Indiana, Figures 6 and 7) after midnight on the 22 June 2002 continuing into the morning of that day. This would allow enhanced particulate settling to occur once again over the Indianapolis area.
- The development, as was the case the previous day, of a pronounced area of confluent streamlines over central Indiana, Figure 8. The surface air mass being transported into central Indiana at this time originates primarily over north central Indiana. However, by evening (Figure 9) the origin of the air mass being transported into the Indianapolis area has shifted to southeastern Indiana and southwestern Ohio.

The upper-level streamline analysis (Figures 10 through 24) shows that Indiana and surrounding states were increasingly coming under the influence of an upper-level anticyclone (i.e., high pressure area, represented by an anticyclonic swirl in the streamlines). This anticyclone not only tilted southwestward with height, but also retrograded from central Ohio to north central Indiana during the period of interest. This feature would most likely have limited vertical mixing (i.e., overturning) of the lowest layers of the atmosphere over central Indiana during 21 June 2002 and 22 June 2002 thus trapping atmospheric pollutants that were present close to the surface.

In the episode examined, there appears to exist a correlation between high ground-level ozone values and high $PM_{2.5}$ values recorded in the Indianapolis, Indiana area for the period 21 June 2002 to 22 June 2002. Although, high ground-level ozone values are usually observed during the period 1 May to 30 September, high $PM_{2.5}$ values can be observed throughout the year. However, in this case atmospheric variables conducive to the formation of ground-level ozone, i.e., light winds, warm temperatures, and little vertical mixing of the air mass not only contributed to ground-level ozone formation, but also to the trapping of already existing fine particulate matter and/or the formation through chemical transformation of gaseous pollutants into $PM_{2.5.}$

5. SEASONAL AND GEOGRAPHIC VARIABILITY

It was of interest to see if patterns existed for $PM_{2.5}$ values across geographic areas and throughout different seasons. For instance, when values were high in central Indiana were they also high in other areas or were they consistent throughout the year? Also, were there seasonal patterns such as high values in the winter and low values in the summer? The following analyses attempt to answer those questions.

5.1 Spatial Patterns

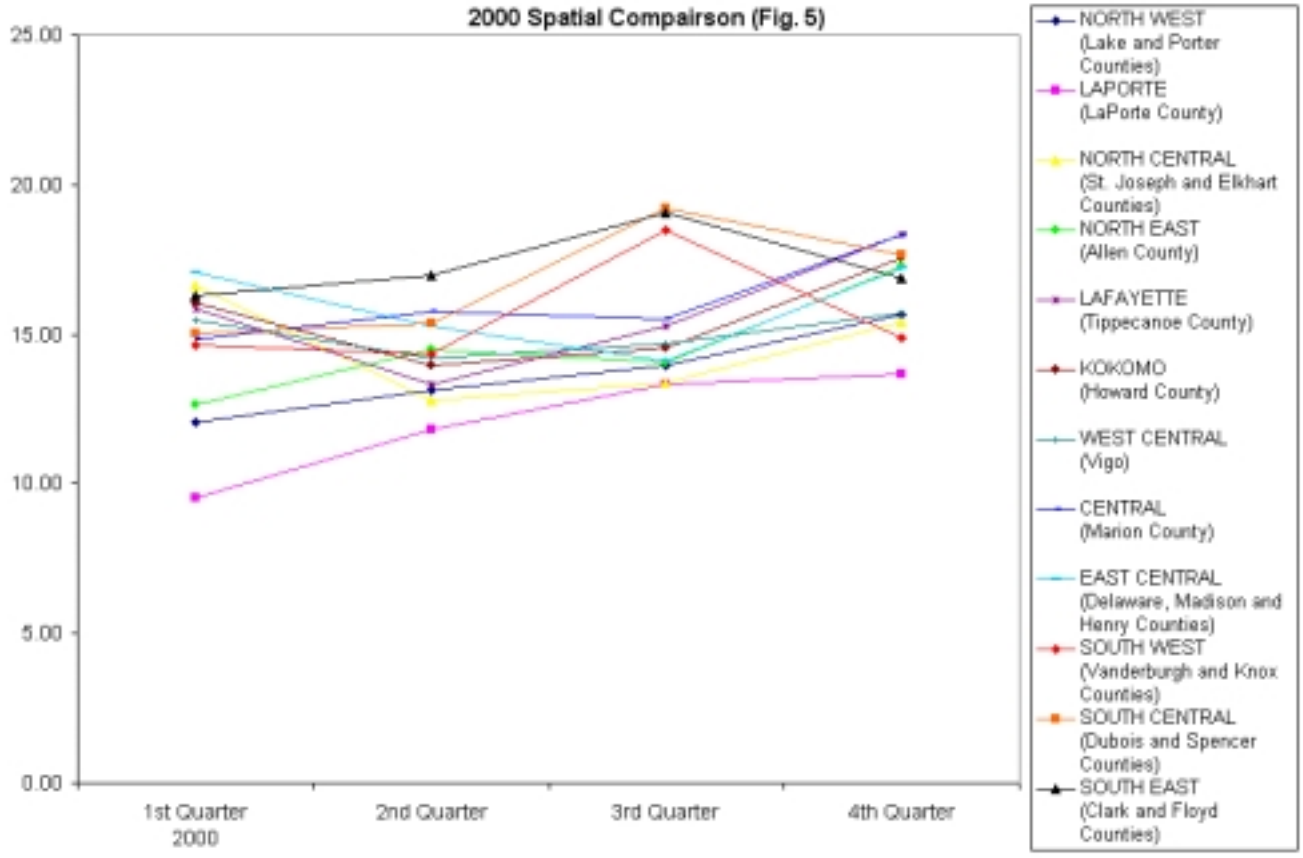
Quarterly averages of $PM_{2.5}$ monitoring data at each monitor for all three years were compared to determine what spatial or geographical patterns existed, if any. 2003 Data will be added once it is quality assured. First the monitors were broken down into twelve geographical areas: North West (Lake and Porter Counties), LaPorte (LaPorte County), North Central (St. Joseph and Elkhart Counties), North East (Allen County), Lafayette (Tippecanoe County), Kokomo (Howard County), West Central (Vigo County), Central (Marion County), East Central (Delaware, Madison and Henry Counties), South West (Vanderburgh and Knox County), South Central (Dubois and Spencer Counties) and South East (Clark and Floyd Counties). For the years 2000 through 2002, almost all the monitors followed the same pattern. Overall it was found that the monitors in Southern Indiana (Dubois, Jeffersonville, New Albany and Evansville) had higher values when compared to the rest of the state. Jeffersonville recorded the overall highest averages in every year and along with Dubois, New Albany and Evansville experienced large spikes in the third quarter. Over a three year period large spikes were seen in a fair number of monitors in the third quarter, suggesting $PM_{2.5}$ values will be highest during that time. LaPorte was found to have the lowest values in the state which is significant because the surrounding areas continually recorded higher values throughout the year. Geographically $PM_{2.5}$ is similar across the state, with higher values in Southern Indiana and lower values in LaPorte.

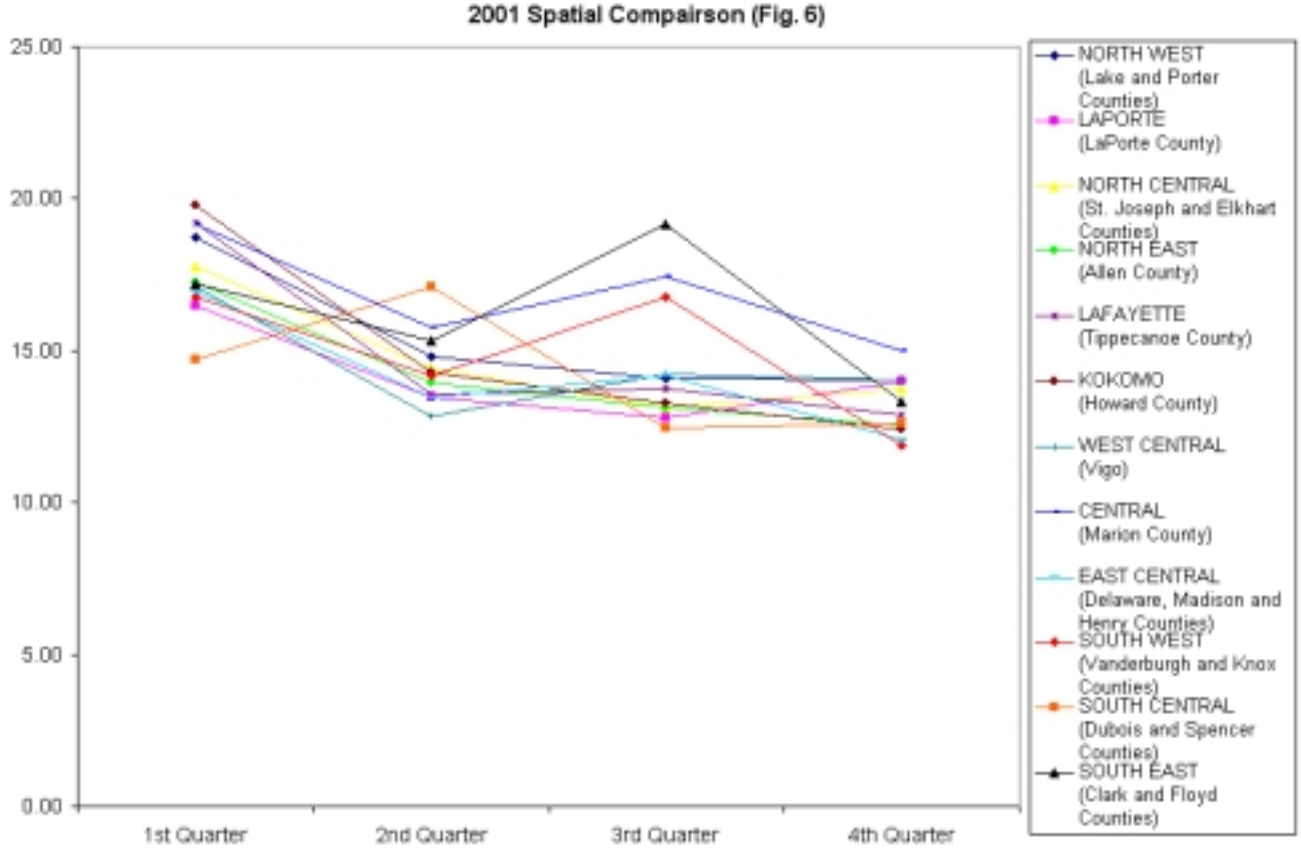
In the year 2000 a general pattern of decrease was seen from the first to second quarter and then an increase from the second to the fourth quarter. The South Central monitors in Dubois and Spencer counties spiked in the third quarter recording the highest average for the year. From the third quarter to the forth quarter a slight increase was seen in all areas except the Southeast, South Central and Southwest monitors which decreased. The highest overall quarterly averages of $PM_{2.5}$ were recorded in Southeast, while the lowest values were recorded in the Northwestern city of LaPorte. The low values recorded in LaPorte are significant, because the surrounding Northwestern and Northcentral areas recorded values at least 2 $\mu g/m^3$ higher than LaPorte's throughout the year. Overall higher values were seen in Southern Indiana than the rest of the state.

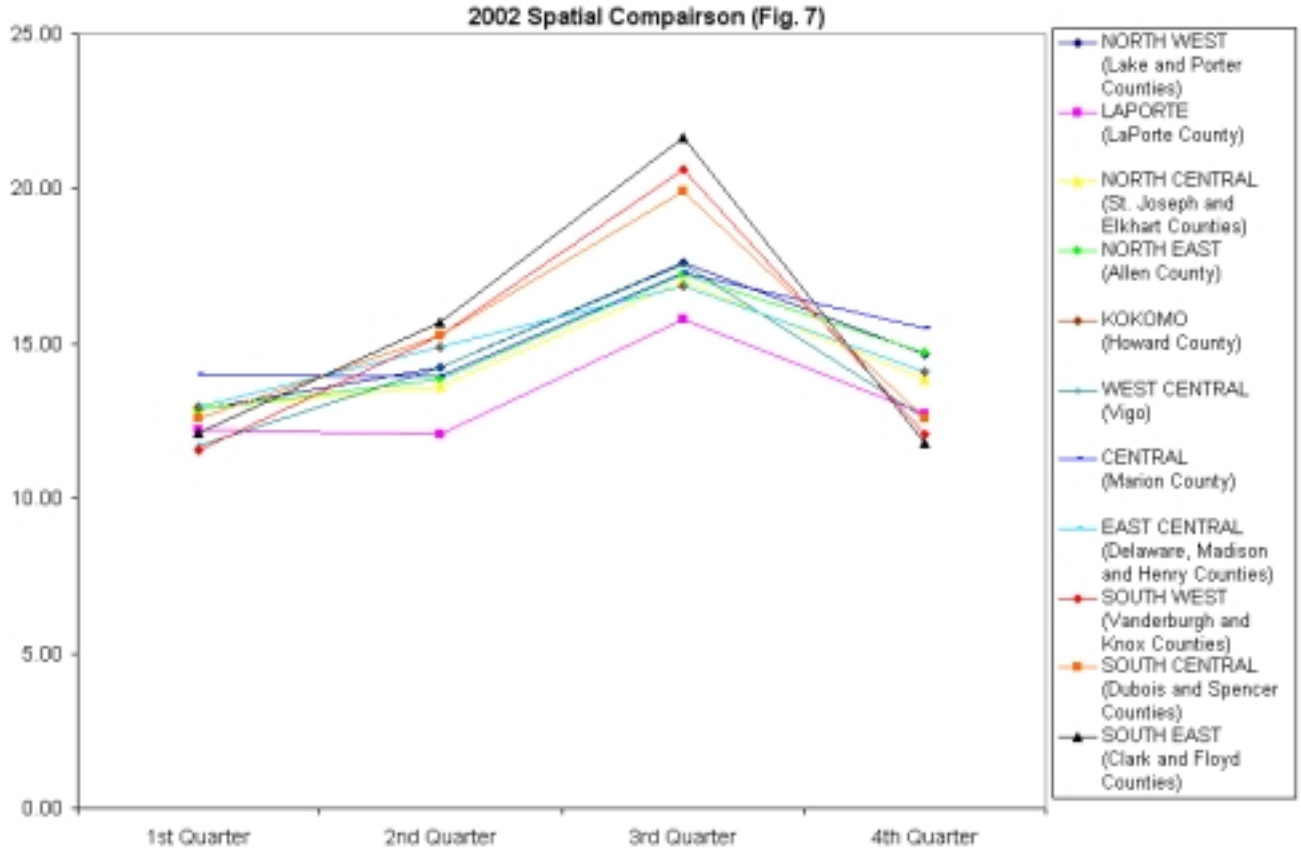
In the year 2001 a general pattern of decrease was seen from the first quarter through the forth quarter. Every monitor decreased from the first quarter to the second quarter except the South Central monitors which increased. From the second quarter to the third almost all monitors decreased. The exceptions were that the Southeastern, Southwestern and Central monitors all increased from the second quarter to the third quarter. Also in the third quarter the monitors in Southeastern Indiana showed a sharp increase and recorded the highest average of the year. From the third quarter to the forth quarter $PM_{2.5}$ values leveled off and didn't change much for most of the monitors. The highest overall quarterly averages of $PM_{2.5}$ were recorded in Southeastern Indiana, while the lowest values were again recorded in the North Western city of LaPorte. The low values recorded in LaPorte are significant, because the surrounding North Western and North Central areas recorded values at least 2 $\mu g/m^3$ higher than LaPorte's throughout the year. Overall higher values were seen in Southern Indiana than the rest of the state.

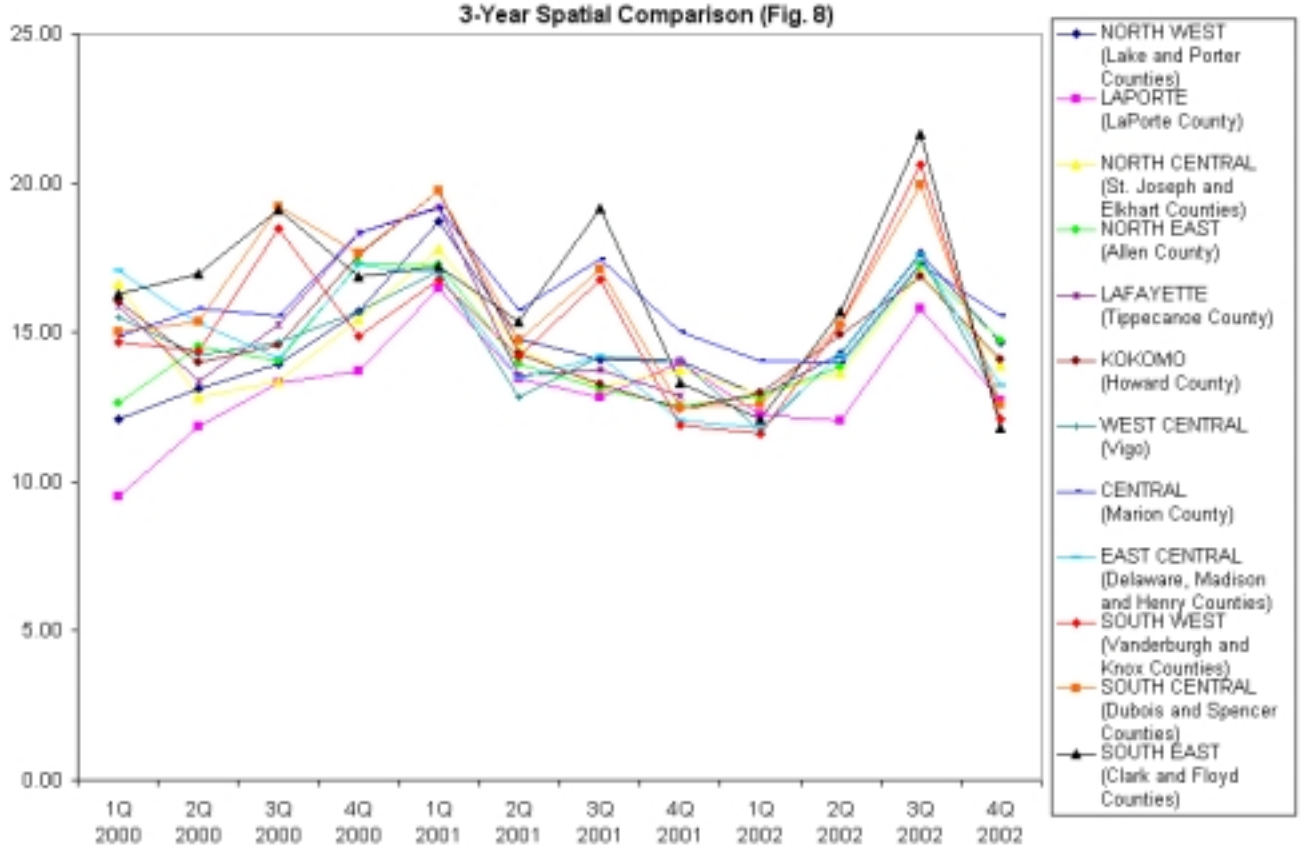
In the year 2002 a general pattern of increase was seen from the first to the third quarter and then a decrease from the third to the forth quarter. Every monitor increased from the second quarter to the third quarter and in the third quarter Southeastern, South Central and Southwestern monitors showed a sharp increase and recorded the three highest averages for the year. It should also be noted that from the third quarter to the forth quarter both the Southeastern, South Central and Southwestern monitors went from having the highest averages to the lowest. The highest overall quarterly averages of $PM_{2.5}$ were recorded in the Southeastern monitors, while the lowest values were again recorded in the North Western city of LaPorte. The low values recorded in LaPorte are significant, because the surrounding North Western and North Central areas recorded values at least 2 $\mu g/m^3$ higher than LaPorte's throughout the year. The Lafayette monitor is not included in this analysis of the year 2002 because of the monitor being shut down in July of 2002. Since no data was collected during this time the quarterly averages could not be calculated. Overall higher values were seen in Southern Indiana than the rest of the state.

Visual comparisons of the spatial patterns for each region of the state by quarter for 2000, 2001 and 2002 and a three year analysis follow.


2000 Spatial Compairson (Fig. 5)
25.00
20.00
15.00
10.00
5.00
0.00
1st Quarter 2000
2nd Quarter
3rd Quarter
4th Quarter
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
LAFAYETTE (Tippecanoe County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)


2001 Spatial Compairson (Fig. 6)
25.00
20.00
15.00
10.00
5.00
0.00
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
LAFAYETTE (Tippecanoe County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)


2002 Spatial Compairson (Fig. 7)
25.00
20.00
15.00
10.00
5.00
0.00
1st Quarter
2nd Quarter
3rd Quarter
4th Quarter
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)


3-Year Spatial Comparison (Fig. 8)
25.00
20.00
15.00
10.00
5.00
0.00
1Q 2000
2Q 2000
3Q 2000
4Q 2000
1Q 2001
2Q 2001
3Q 2001
4Q 2001
1Q 2002
2Q 2002
3Q 2002
4Q 2002
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
LAFAYETTE (Tippecanoe County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)

5.2 Temporal Profiles

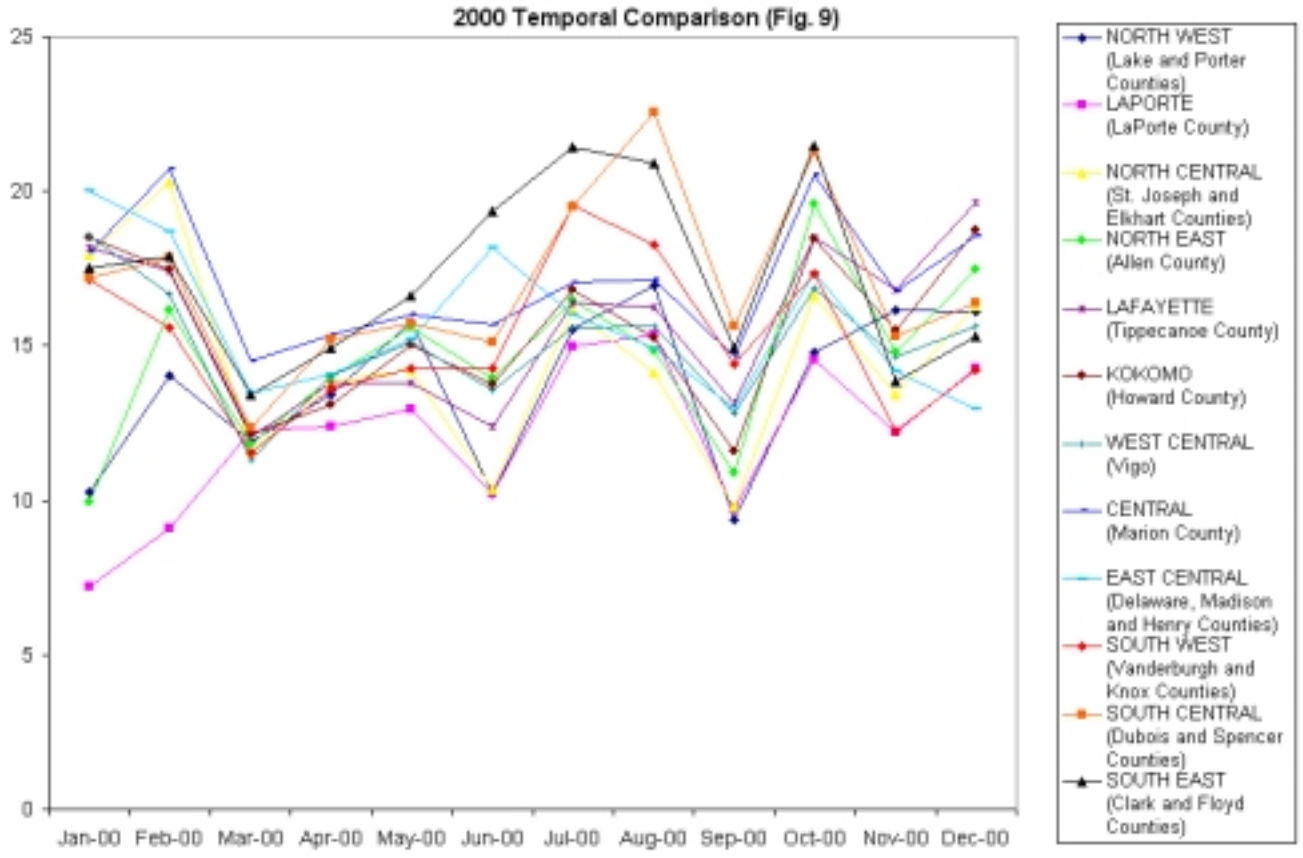
Monthly averages of $PM_{2.5}$ monitoring data at each individual monitor for all three years were compared to determine what temporal or seasonal patterns existed, if any. 2003 Data will be added once it is quality assured. First the monitors were broken down into twelve geographical areas: North West (Lake and Porter Counties), LaPorte (LaPorte County), North Central (St. Joseph and Elkhart Counties), North East (Allen County), Lafayette (Tippecanoe County), Kokomo (Howard County), West Central (Vigo County), Central (Marion County), East Central (Delaware, Madison and Henry Counties), South West (Vanderburgh and Knox Counties), South Central (Dubois and Spencer Counties) and South East (Clark and Floyd Counties). For the years 2000 through 2002, almost all of the monitors followed the same pattern. Over a three year period $PM_{2.5}$ monthly averages vary a lot but it was found that $PM_{2.5}$ values were highest in the summer and in the winter. Overall it was found that $PM_{2.5}$ values are higher in the summer when compared to the winter. The monitors in Southern Indiana (Dubois, Jeffersonville, New Albany and Evansville) had higher values when compared to the rest of the state. The Southeastern monitors recorded the highest averages in almost every month and along with Dubois, New Albany and Evansville experienced large spikes in the third quarter. LaPorte was found to have the lowest values in the state which is significant because the surrounding areas continually recorded higher values throughout the year.

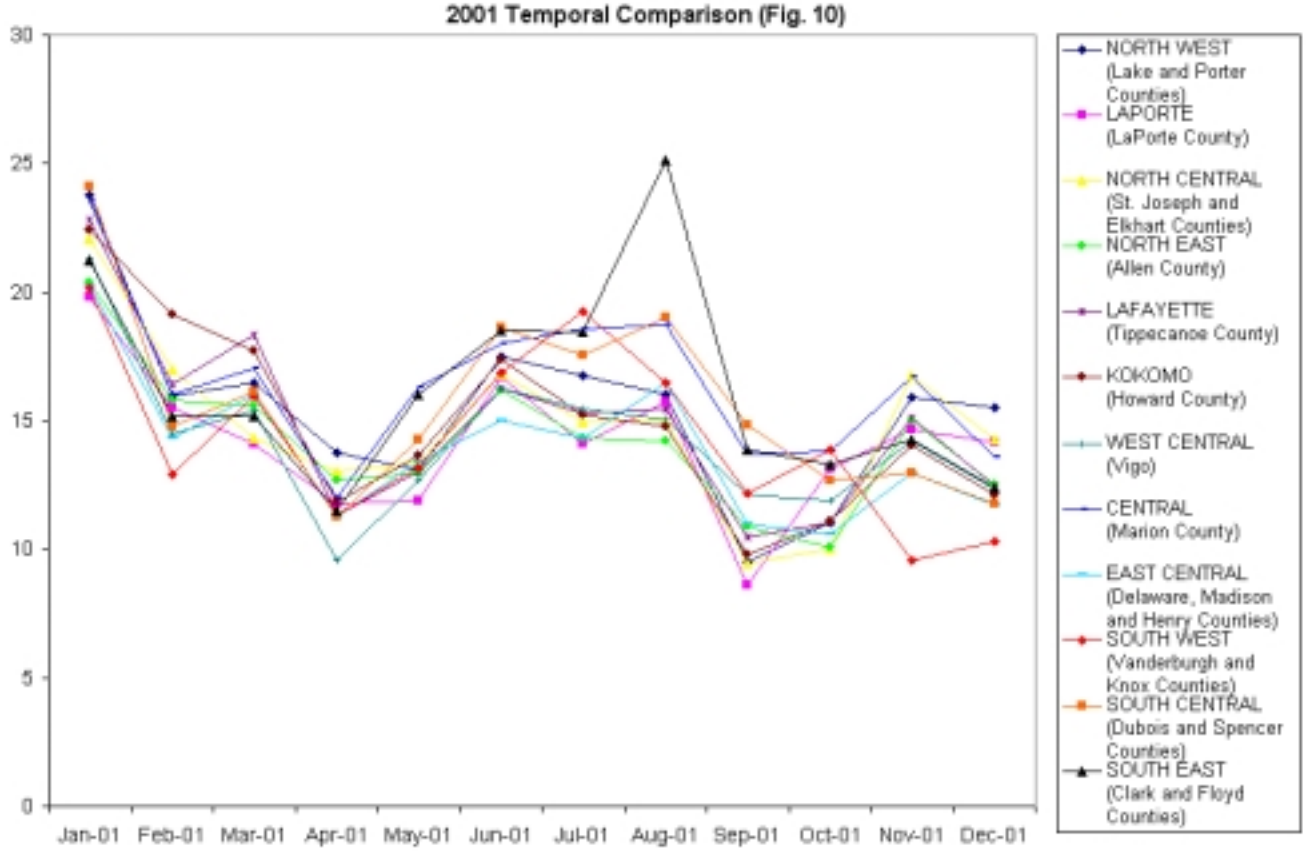
In the winter of 2000, most monitors had high values at the beginning of January and increased slightly to the middle of February. Gary and Fort Wayne increased the most in the winter months. All monitors declined sharply in March except for LaPorte, which increased from February to March. The spring months of 2000 had showed increased values of $PM_{2.5}$ from March to May and the Southeastern monitors recorded the highest averages in the spring. Almost all of the monitors decreased from May to June and then increased in July staying steady through August. The summer months of July and August showed large increases in the Southern monitors of Jeffersonville, New Albany and Evansville. Evansville showed the largest increase from June to July. The Southeastern monitors recorded the highest values for the summer and the South Central monitors recorded the highest for the whole year. All of the monitors decreased from August to September and then spiked in October. October showed values close to the winter months at the beginning of the year. The Southeastern monitors recorded the highest value for autumn and in October recorded the highest value for the whole year. From October to November all the monitors decreased and then increased into December and winter. The largest overall increase occurred in autumn while the largest overall decrease was found from winter to spring months. The highest overall average for $PM_{2.5}$ of any month for the year 2000 occurred in October while the lowest averages were found in September.

The year 2001 was very different from the previous year. A large increase in $PM_{2.5}$ values were seen from December 2000 to January 2001 and then a large decrease was seen from January to February in every monitor. Unlike the year 2000 where there was a decreased value from winter to spring an increase was seen from February to March in all monitors for the year 2001. The spring months recorded a decrease in every monitor from March to April and then an increase from April to the summer month of June. The Southeastern monitors had the largest increase from April to June. Most of the monitors experienced a decrease from June to August in the summer. The monitors in Southeastern Indiana spiked in August and recorded the highest averages for the year. All monitors decreased from August to September and then slowly increased into November. $PM_{2.5}$ values stayed the same from November to December for most of the monitors. The largest overall increase occurred from spring to summer in April to June while the largest overall decrease was found from January to February in the winter months. The highest overall average for $PM_{2.5}$ for any month for the year 2001 occurred in January while the lowest averages were found in September.

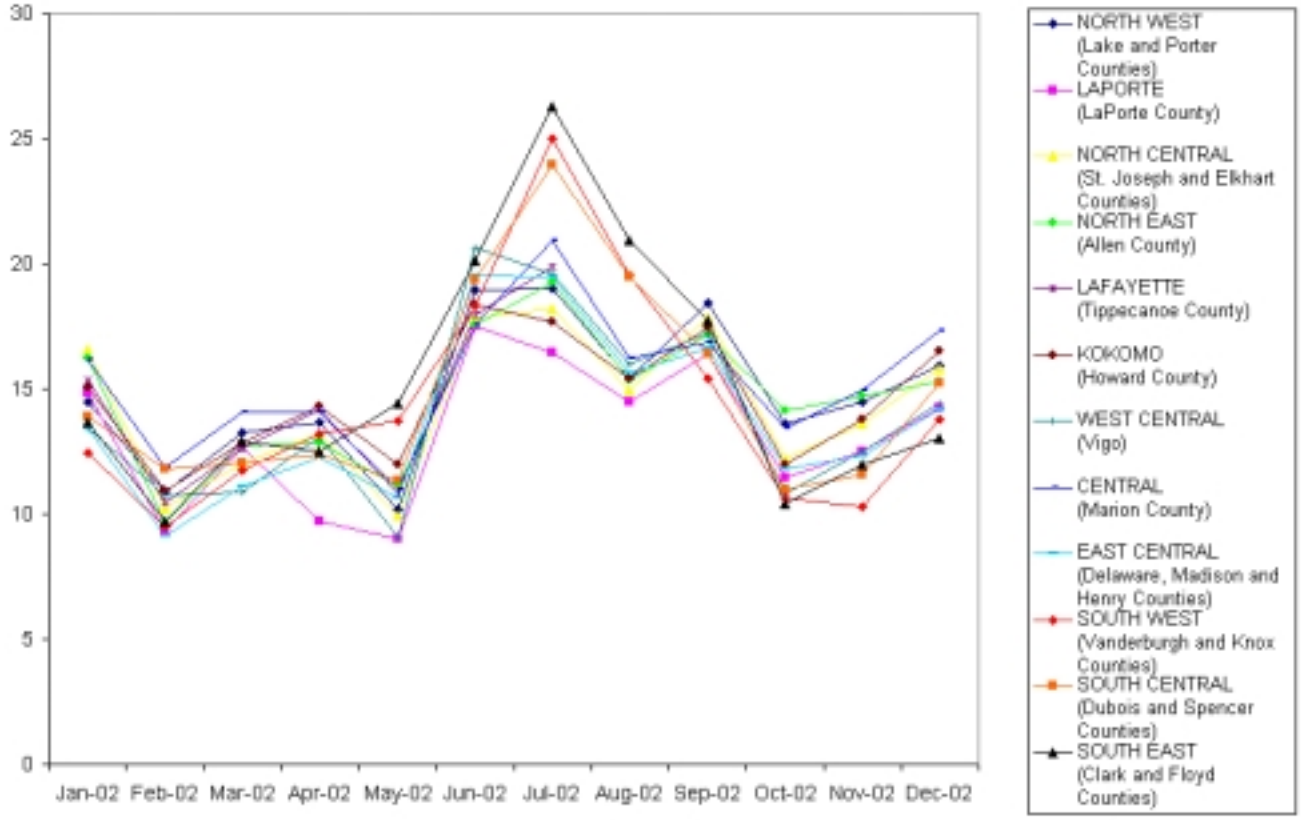
The year 2002 was very different from the previous two years. A large increase in $PM_{2.5}$ values were seen from December 2001 to January 2002 and then a large decrease was seen from January to February in every monitor. Like the year 2001 $PM_{2.5}$ values increased from winter to spring from the months of February to April. In April most monitors decreased from April to May in the spring. Every monitor increased from May to June and most were steady between June and July. The Southeastern, South Central and Southwestern monitors continued to increase in the summer month of July and recorded the highest averages for the year. Every monitor decreased from July to August and most increased from August to September. From September to October every monitor decreased and then slowly increased into December. The monitors in Southeastern, South Central and Southwestern Indiana experienced a large decrease from the summer to the middle of autumn. The largest overall increase occurred from spring to summer in May to June while the largest overall decrease was found in autumn from September to October. The highest overall average for $PM_{2.5}$ for any month for the year 2002 occurred in July while the lowest averages were found in February. The Lafayette monitor is not included in this analysis of the year 2002 because of the monitor being shut down in July of 2002. Since no data was collected during this time the monthly averages could not be calculated.

Visual comparisons of the temporal patterns for each region of the state by month for 2000, 2001 and 2002 and a three year analysis follow.

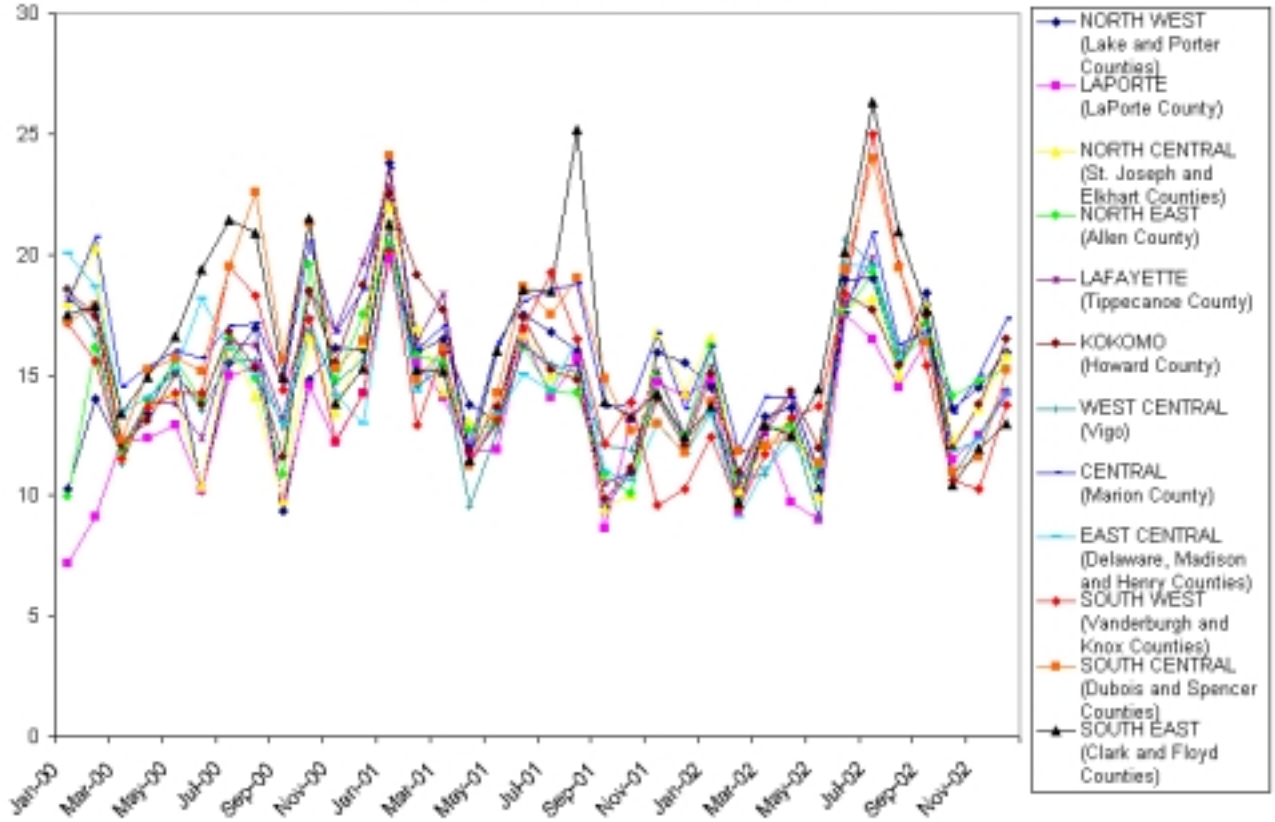

2000 Temporal Comparison (Fig. 9)
25
20
15
10
5
0
Jan-00
Feb-00
Mar-00
Apr-00
May-00
Jun-00
Jul-00
Aug-00
Sep-00
Oct-00
Nov-00
Dec-00
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
LAFAYETTE (Tippecanoe County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)


2001 Temporal Comparison (Fig. 10)
30
25
20
15
10
5
0
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
NORTH WEST (Lake and Porter Counties)
LAPORTE (LaPorte County)
NORTH CENTRAL (St. Joseph and Elkhart Counties)
NORTH EAST (Allen County)
LAFAYETTE (Tippecanoe County)
KOKOMO (Howard County)
WEST CENTRAL (Vigo)
CENTRAL (Marion County)
EAST CENTRAL (Delaware, Madison and Henry Counties)
SOUTH WEST (Vanderburgh and Knox Counties)
SOUTH CENTRAL (Dubois and Spencer Counties)
SOUTH EAST (Clark and Floyd Counties)

2002 Temporal Comparison (Fig. 11)



3-Year Temporal Comparison (Fig. 12)



6. SPECIATED DATA

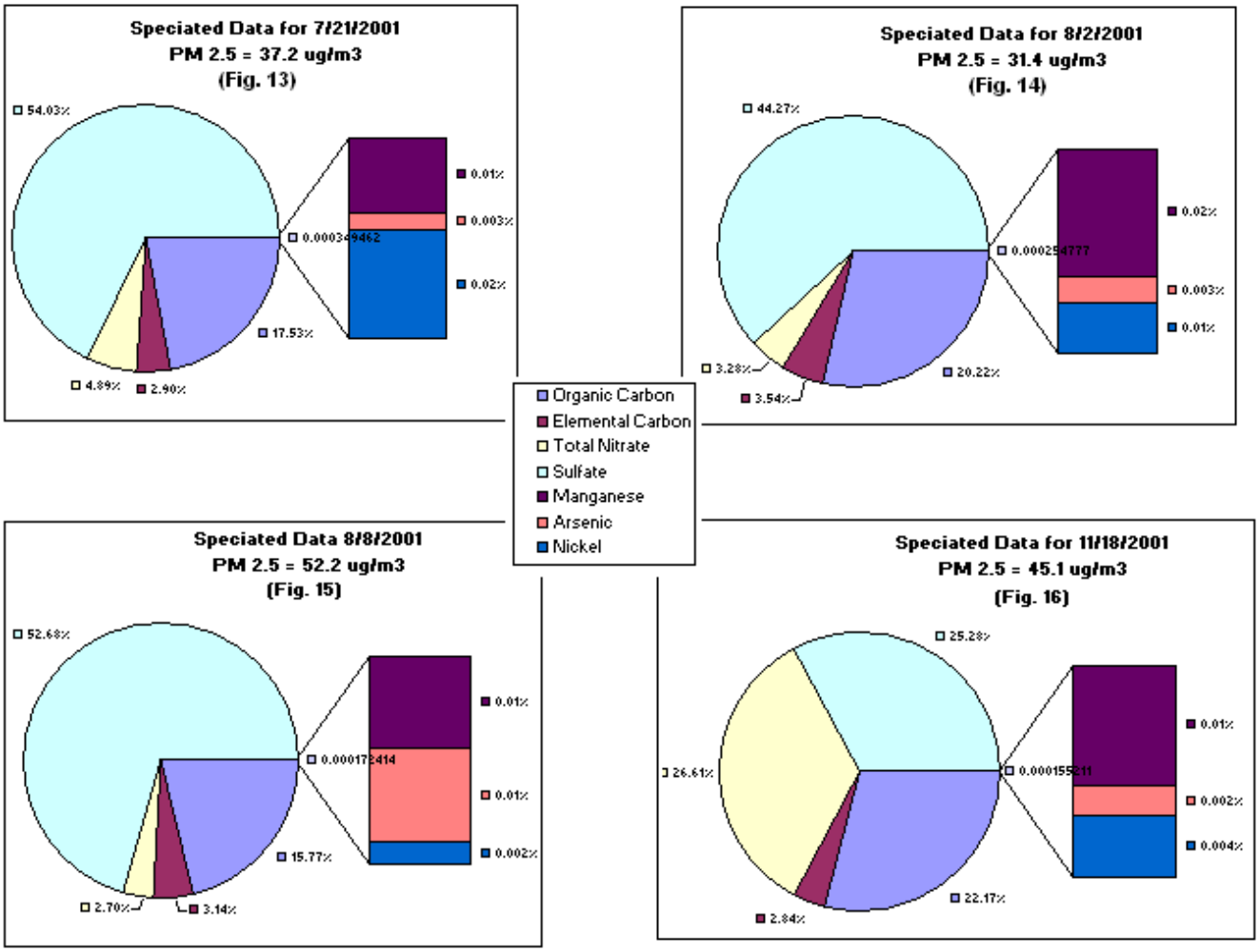
An analysis was conducted to see what species of pollutants existed in the $PM_{2.5}$ that was monitored. This included a breakdown by species for the four highest $PM_{2.5}$ values that were recorded as well as a quarterly breakdown of those species.

6.1 Speciated Data Findings

Speciated data were collected to determine what species of pollutants were present in the $PM_{2.5}$ that was measured. There are currently five monitors that measure speciated data. Data is available for only two monitor sites in Indiana located in Indianapolis at Washington Park and began operation in 2001, the other is located in Mechanicsburg in Henry County and began operating in 2002. The other three monitors that measure speciation did not begin operation until 2003 and data will be added once it is quality assured. At the Indianapolis and Mechanicsburg monitors the four highest $PM_{2.5}$ values were noted and an assessment was made using those values compared to the values for the species of concern on those days. Seven pollutants were measured, including organic carbon, elemental carbon, total nitrate, sulfate, manganese, arsenic and nickel. Sulfate contributed to higher $PM_{2.5}$ values in the summer and Nitrate contributed to higher values in winter. This is consistent with what has been found in similar analysis done by LADCO and EPA. Please refer to the figures below for a summary and a visual comparison of the results.

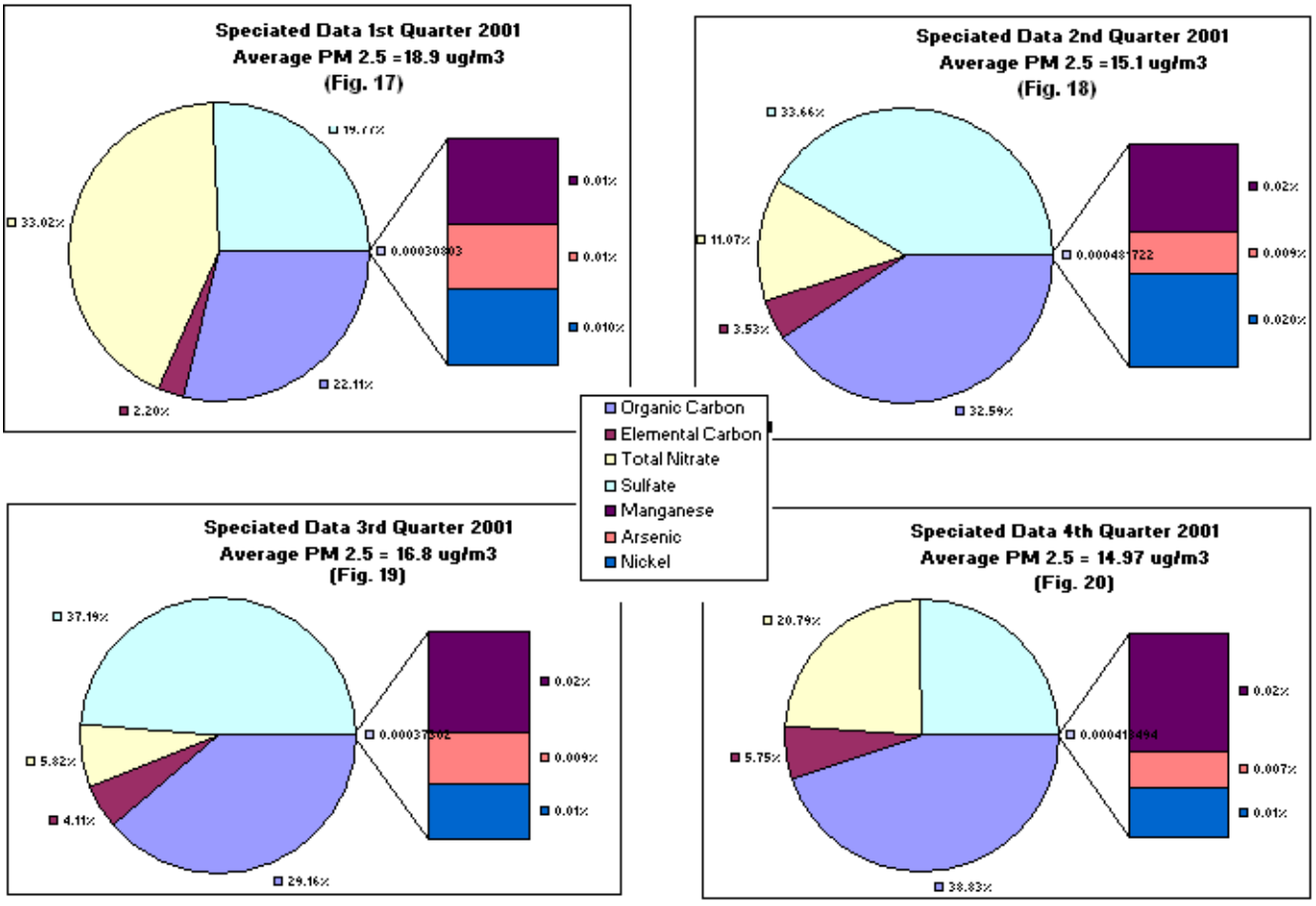
In 2001 at the Washington Park site in Indianapolis the highest $PM_{2.5}$ value occurred on August 8 with a reading of 52.2 $\mu g/m^3$. Sulfates contributed 52.68% to that value, while organic carbon comprised 15.77%. July 21st and August 2nd also showed high values of $PM_{2.5}$ with sulfates contributing the most with organic carbon closely behind. On November 18, 2001, when $PM_{2.5}$ was 45.1 $\mu g/m^3$, nitrates contributed the most with 26.61%, closely followed by sulfates contributing 25.28% and organic carbon contributing 22.17%. A breakdown of the $PM_{2.5}$ 2001 constituents on the four highest days can be found below.

Indianapolis Washington Park Data



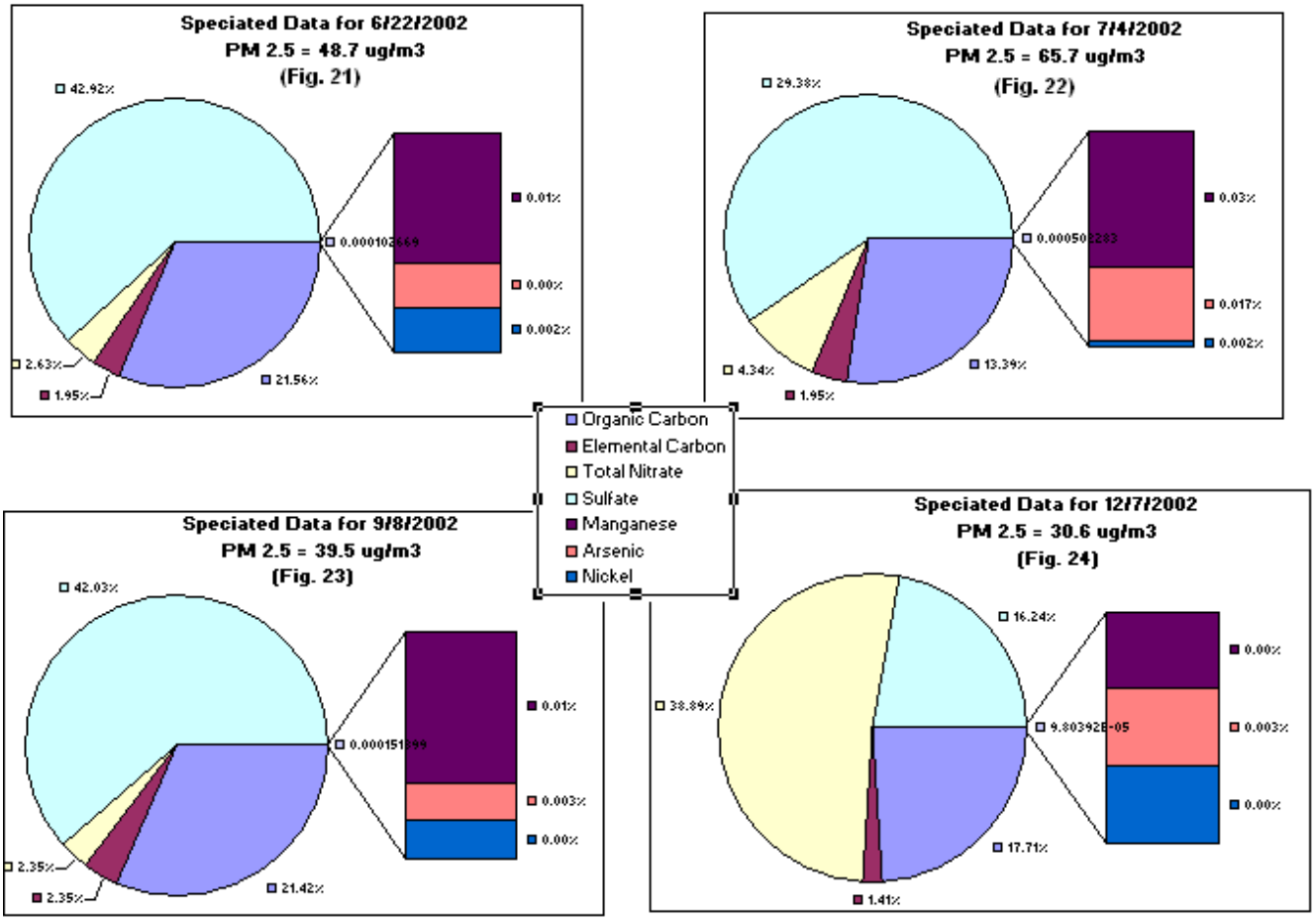
At the Washington Park site in Indianapolis the highest $PM_{2.5}$ average concentration of 18.93µg/m^3 occurred in the First Quarter of 2001. Total nitrate contributed 33.02% to that value, while organic carbon and sulfate followed closely with 22.11% and 19.77% respectively. The second quarter of 2001 showed that sulfate and organic carbon contributed almost evenly with 33.66% and 32.59%. The third quarter was very close to the second quarter also showing that sulfate and organic carbon contributed the most. The forth quarter showed that organic carbon contributed the most with 38.83% followed by sulfates and total nitrate. A quarterly breakdown of the $PM_{2.5}$ 2001 constituents can be found below.

Indianapolis Washington Park Data



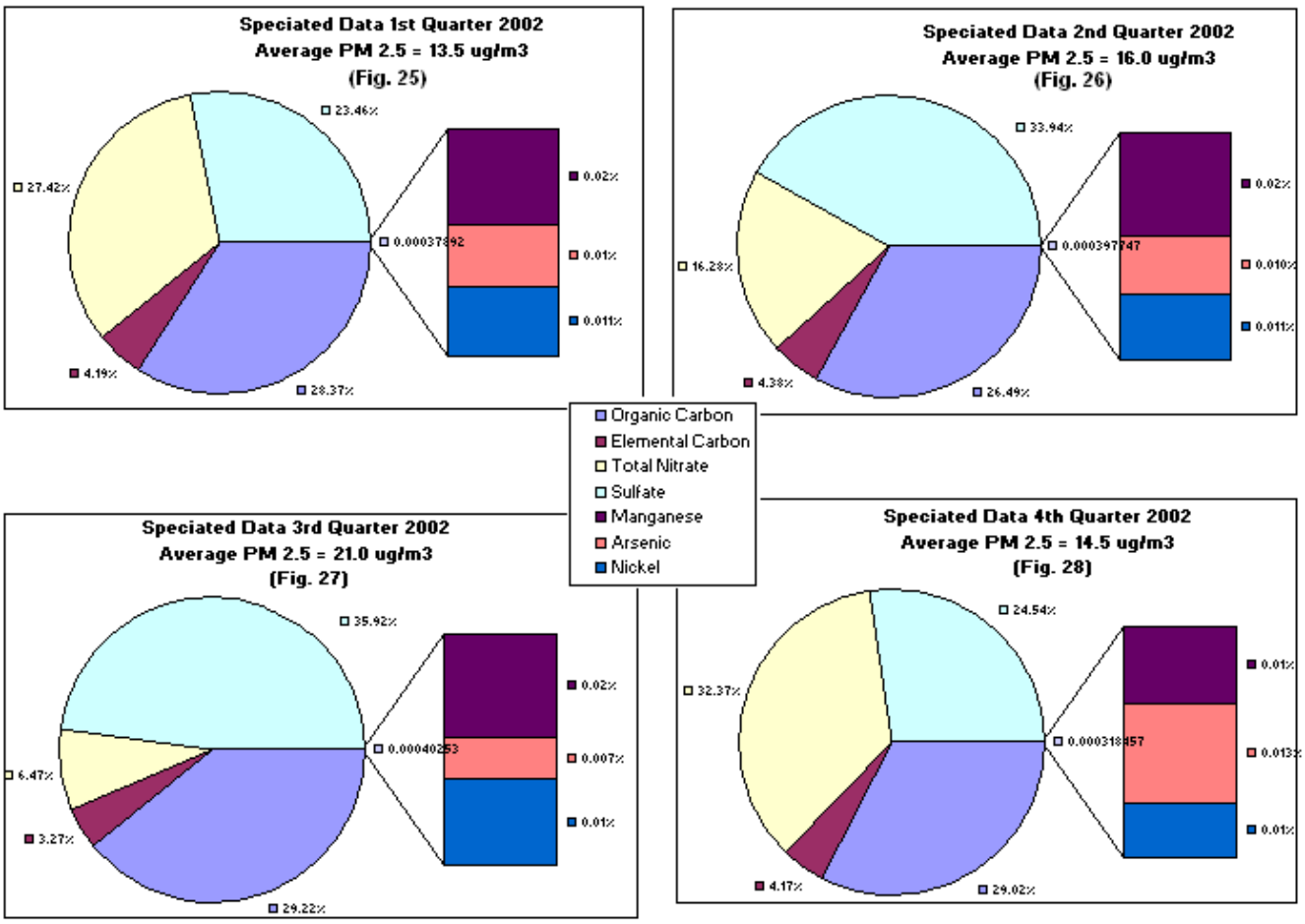
In 2002 at the Washington Park site in Indianapolis the highest $PM_{2.5}$ value occurred on July 4 with a reading of 65.7 µg/m^3. Sulfates contributed 29.38% to that value, while organic carbon comprised 13.39%. June 22nd and September 8th also showed high values of $PM_{2.5}$ with sulfates contributing the most with organic carbon closely behind. On December 7, 2001, when $PM_{2.5}$ was 30.6 µg/m^3, nitrates contributed the most with 38.89%, followed by organic carbon contributing 17.71% and sulfate contributing 16.24%. A breakdown of the $PM_{2.5}$ 2002 constituents on the four highest days can be found below.

Indianapolis Washington Park Data



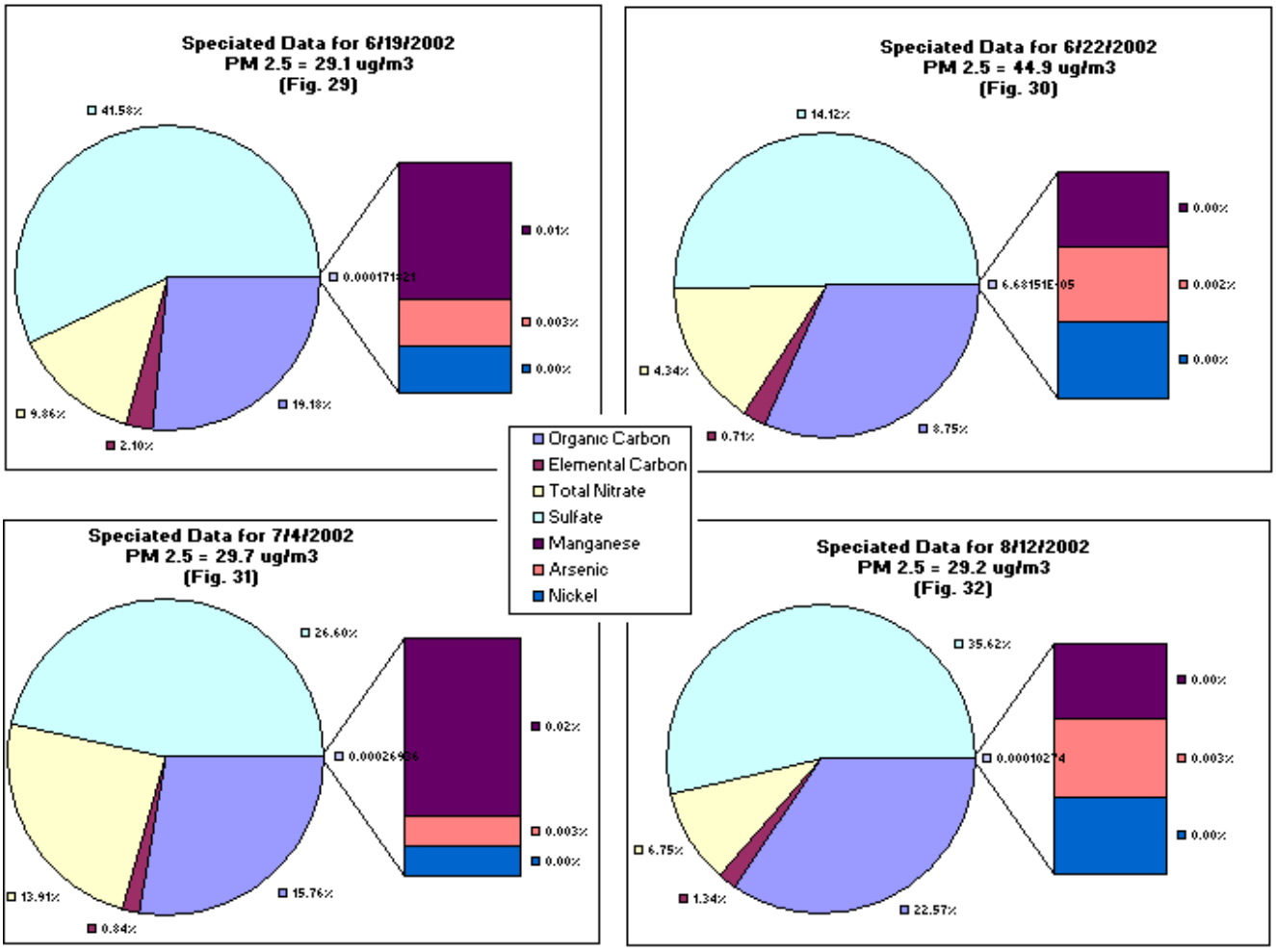
At the Washington Park site in Indianapolis the highest $PM_{2.5}$ average concentration of 21.0 $\mu g/m^3$ occurred in the third quarter of 2002. Sulfates contributed 35.92% to that value, while organic carbon comprised 29.22%. The first quarter of 2002 showed that organic carbon and total nitrate contributed almost evenly with 28.37% and 27.42%; sulfates followed closely with 23.46%. The second quarter showed that sulfates contributed 33.94% followed by Organic Carbon with 26.49%. The forth quarter was very close to the first quarter showing that total nitrate and organic carbon contributed almost evenly with 32.37% and 29.02%, sulfates followed closely with 24.54%. A quarterly breakdown of the $PM_{2.5}$ 2002 constituents can be found below.

Indianapolis Washington Park Data



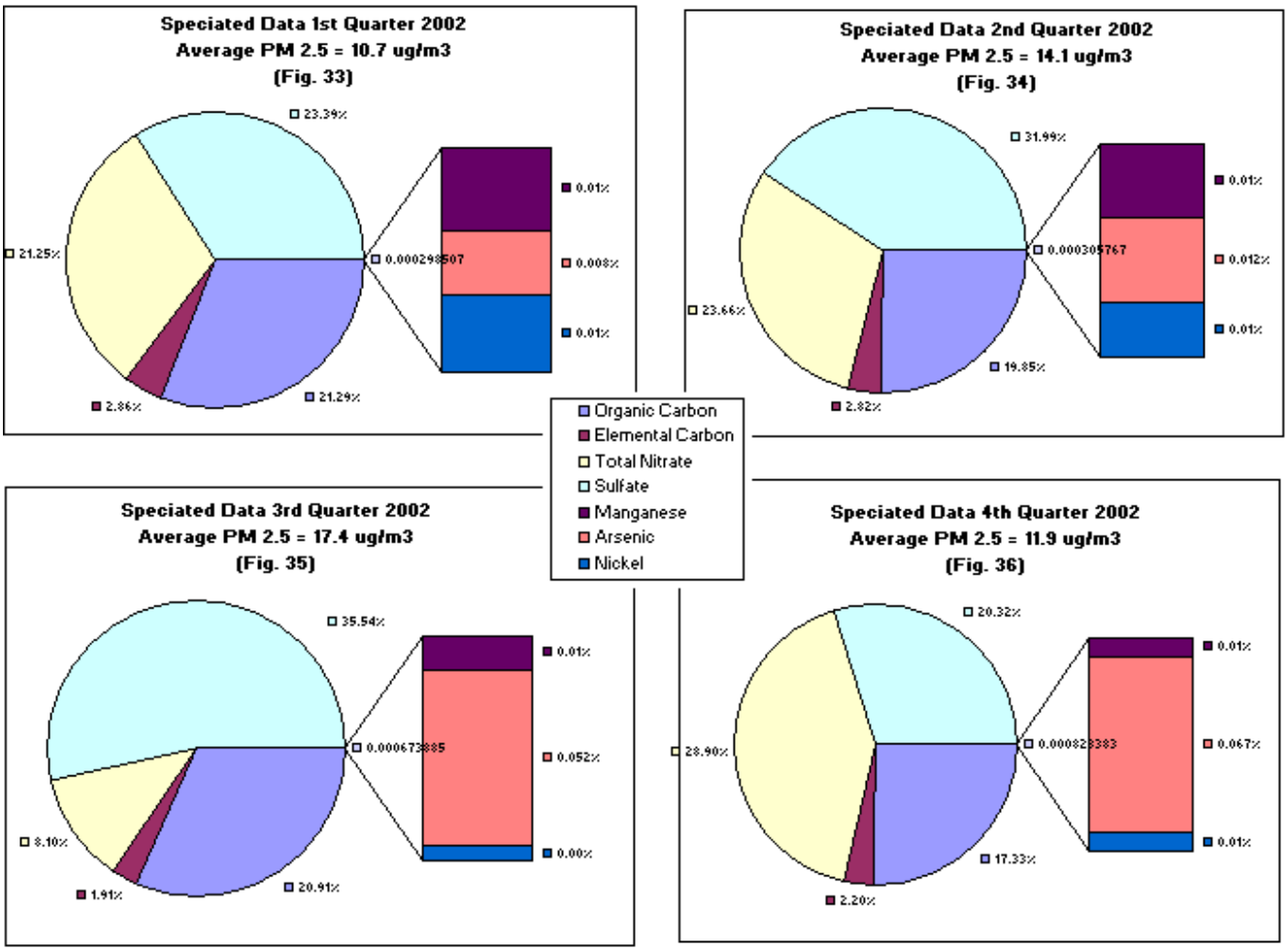
In 2002 at the Mechanicsburg site in Henry County the highest $PM_{2.5}$ value occurred on June 22 with a reading of 44.9 $\mu g/m^3$. Sulfates contributed 14.12% to that value, while organic carbon comprised 8.75%. June 19th, July 4th and August 12th also showed high values of $PM_{2.5}$ with sulfates contributing the most with organic carbon closely behind. A breakdown of the $PM_{2.5}$ 2002 constituents on the four highest days can be found below.

Henry County Mechanicsburg Data



At the Mechanicsburg site in Henry County the highest $PM_{2.5}$ average concentration of 17.4 µg/m^3 occurred in the third quarter of 2002. Sulfates contributed 35.54% to that value, while organic carbon comprised 20.91%. The first quarter of 2002 showed that sulfates contributed the most with 23.39%. Organic carbon and total nitrate contributed almost evenly with 21.29% and 21.25%. The second quarter showed that sulfates contributed 31.99% followed by total nitrate with 23.66%. The forth quarter showed that total nitrate contributed the most with 28.90%. Sulfate and organic carbon contributed with 20.32% and 17.33%. A quarterly breakdown of the $PM_{2.5}$ 2002 constituents can be found below.

Henry County Mechanicsburg Data



7. CONCLUSIONS

The following conclusions have been made as a result of this analysis of the Indiana $PM_{2.5}$ monitoring network:

- Seven counties currently exceed the annual $PM_{2.5}$ standard
    - Lake, Elkhart, Marion, Vanderburgh, Dubois, Clark and Floyd counties exceed based on a 3-year average.
- The entire state of Indiana is in attainment for the 24-hour $PM_{2.5}$ standard.
- $PM_{2.5}$ values appear to be uniform regardless of the urban or rural status of the monitored areas.
- During episodes of high ozone, elevated levels of $PM_{2.5}$ should also be expected.
- The majority of the State's regions show similar patterns of $PM_{2.5}$ values throughout the three year period. Seasonally higher values were found during the summer and geographically higher values were seen in Southern Indiana.
- Higher $PM_{2.5}$ values were found in Chicago, IL when compared to Gary, IN. Higher $PM_{2.5}$ values in Kentucky were also found when Henderson, KY was compared to Evansville, IN and Louisville, KY was compared to New Albany, IN.
- The most prevalent species of pollutants present in Indiana's fine particulate matter throughout the year are sulfates, nitrates and organic carbons. Sulfates contribute the most to $PM_{2.5}$ values in the summer and nitrates contribute the most during the winter.